INTERACTION OF CUES, LEARNER CURIOSITY, VERBAL ABILITY, AND AMOUNT OF INVESTED MENTAL EFFORT WITH ACHIEVEMENT IN A MUSEUM SETTING

By

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This is lovingly dedicated to the memory of my parents, Mr. and Mrs. Victor G. Mauer, Sr., whose unwavering faith in my ability to succeed at anything I attempted sustained me throughout this project.

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This study investigated the effects that resulted from treatments that differed in the presence or absence of both attention cues and test cues upon learning from a shell museum exhibit. The relationship between students' curiosity prior to, and after, their exposure to a hands-on museum exhibit was also explored. Finally, the interactions of learner characteristics with the above treatments were investigated.

One hundred twenty-nine sixth grade students were randomly assigned to one of four treatments in a modified posttest only design. Subjects were given aptitude tests representing verbal ability and prior science curiosity which were thought to be differentially related to achievement. Exploratory psychomotor curiosity of each subject was timed while each was in the vicinity of the shell exhibit. All subjects were then given posttest measures of invested mental effort, curiosity, and achievement.

Regression analyses revealed no significant main effects for the variance in attention cues or in test cues; merely supplying these cues did not ensure learning. However, this was not discouraging; rather, a significant three-way interaction (p = .04) of Verbal Ability x Attention Cues x Test Cues was detected with the recall of factual items. Subjects high in verbal ability learned more when the treatment contained test cues, but no attention cues, while low verbal ability subjects could not process the incoming information from the exhibit without the attention cues that provided them with a device for organizing, coding, and remembering the information.

A significant main effect for mental effort was detected (p = .039). Subjects who invested more mental effort made more and better inferences than those who invested less mental effort. A test cue only treatment seemed to influence students to perceive the task as important to learn; thus they made superior inferences.

A significant interaction (p = .04) with the Amount of Psychomotor Curiosity x Test cue was found for posttest science curiosity. A no test cue treatment produced higher posttest science curiosity scores for both high and low curiosity subjects because the subjects could pursue their curious ideas without the threat of being tested on content.

CHAPTER I
THE PROBLEM

Purpose

This study had three objectives: (1) to ascertain differences in learning achievement resulting from variations in the cues given to students that preceded their approach to a particular museum exhibit; (2) to investigate the interaction of learner characteristics such as their levels of curiosity, verbal ability, and "invested mental effort" with achievement; and (3) to examine the relationship between the students' curiosity levels prior to, and after, their interaction with a hands-on museum exhibit.

Background to the Problem

Of the more than 300 million people who visit museums annually (Harris Poll, 1980), 40% were found to attend science museums (Tressell, 1980). Since museum design is generally outside of the parameters of traditional formal classroom structure, museums are generally described by researchers, educators, and psychologists as unstructured, with no mandatory objectives, nor attendance requirements; therefore, they are labeled "informal learning settings" (Falk & Balling, 1982; J. J. Koran, Longino, & Shafer, 1983).

People of all ages have visited museums and most have tended to view exhibits aimlessly and for a maximum duration of 30 seconds (Falk, 1983; Nielson, 1946). Since education appeared not to be the primary purpose of their visit, museum goers were usually unable to recall salient information about any of the exhibits they viewed. The attraction for these visitors was entertainment; they saw the unusual and were inclined to seek out exhibits relevant to their own personal intrigue (Laetsch, Diamond, Gottfried, & Rosenfeld, 1980).

The educational role of museums began as a research interest with the Shettel et al. (1968) study. Here, it was determined that exhibits had to attract and maintain the attention of the viewers before the exhibit could communicate its message. This work, and that of others (Abler, 1968; Cronje, 1980; DeWaard, Jagmin, Maisto, & McNamara, 1974; J. J. Koran, Lehman, Shafer, & Koran, 1983; Screven, 1974; Shafer, 1981), detailed the use of various methods for gaining the attention of museum goers. Although the above studies generally reported that viewers had increased attention and focusing times, the relationship of this increased focus of attention to proportionate increases in learning from exhibits is an area that needs further investigation. Thus, one objective of this study was to inquire what effect attention focusing questions (questions related to specific exhibit attributes) would have upon achievement in a museum type informal learning setting.

Although curiosity would seem to play an important role in attention, unfortunately, few curiosity studies have addressed the influence of curiosity upon learning in either the school environment or in the museum (Garcia, 1978; Lowry & Johnson, 1981); therefore, there are little data in this area. Those curiosity studies carried out in museum settings have demonstrated increased interest and increased manipulation attributed to curiosity (J. J. Koran, Morrison, Lehman, Koran, & Gandara, 1984; Oppenheimer, 1972; R. W. Peterson, 1979), but have not unequivocally established what effect curiosity has upon achievement. In order to explore this relationship, a second objective of this study was to determine the impact various levels of curiosity had upon learning from a museum exhibit.

Many researchers have defined curiosity (Banta, Sciarra, & Jeff 1966; Berlyne, 1954, 1966; Kreitler, Ziegler, & Kreitler, 1975; Langevin, 1971; Maw & Maw, 1971; R. W. Peterson, 1979; R. W. Peterson & Lowery, 1972); but curiosity in this study was confined to three aspects: (1) the psychomotor curiosity, or the subjects' manipulation of objects in the exhibit during the time they were in the vicinity of the novel hands-on museum exhibit, (2) the students' written reactive curiosity to certain novel situations as adapted from the Children's Reactive Curiosity Scale (Penney & McCann, 1964, Appendix C), and (3) the subjects' unsolicited questions after their exposure to the exhibit.

The complexity of the human organism suggests that achievement may be due to more than the factors of attention and curiosity. Other characteristics that differ in individuals have been found to interact simultaneously to differentially affect learning. Much evidence has shown that the general ability of subjects accounts for considerable variance in their level of achievement (Cronbach & Snow, 1977). For this reason, verbal ability, as an index of general ability, was pertinent to this study and was also explored in relation to learning.

Effort has long been recognized as an important facet in the process of learning. The amount of invested mental effort (AIME), however, is not merely time spent on a task nor is it persistence, but has been defined by Salomon (1983) as "the number of nonautomatic mental elaborations applied to material" (p.44).

When subjects had an a priori perception of a task as difficult, they invested more effort than when they perceived the task as easy. Accordingly, the greater the level of mental effort expended, the greater the inferential learning by the subjects (Salomon, 1984). The subjects are assumed to choose the level of effort they wish to invest during any learning experience, including that of an informal learning setting. Due to its inherent informality, a museum setting could be perceived by some subjects as "fun" rather than educational while other subjects could perceive it as an enjoyable learning experience. This subject-chosen differentially invested mental effort was investigated here to ascertain its effect upon the subjects' inferential learning; the expenditure of greater effort was deduced from the learners' greater ability to generate inferences and from their self-reports of effort after their confrontation with the experimental exhibit.

Summary

Because so many people of varying abilities are drawn to museums, due to factors ranging from the mundane to the more-or-less profound, their general ability may account for much of what they gain in a museum setting. However, other variables may interact to differentially affect what is learned such as viewers' attentiveness, level of curiosity, and invested mental effort. Although many researchers have advocated the premise that curiosity increases subjects' attentiveness and willingness to manipulate materials, little data are available on the direct relationship between curiosity and the effectiveness of learning. The variability in the amount of mental effort that subjects are willing to invest (which is due to their perception of a task as difficult or easy), their assessment of self-efficacy, and the reward (or payoff) they expect from performing the task also exert influence on their learning outcomes. Research, therefore, is needed to discern what effects verbal ability, level of curiosity, attention cues, and invested mental effort have upon achievement in a museum. The results may delineate how educators may make optimal use of museum exhibits for instructional purposes either in an informal museum setting or in the formal classroom for their particular students.

CHAPTER II
REVIEW OF RELATED LITERATURE

Attention and Learning

Attention, which is selective in both time and scope, has been established as the first student activity necessary in the acquisition of knowledge (Bransford, 1979; Gagné, 1973; Keele, 1973; J. J. Koran & Lehman, 1981). Some students have more attention to give, or want to give, to instruction (Osborne & Wittrock, 1983; Wittrock, 1979). Both the persistence and the intensity of student attention have been shown to affect learning (Bransford, 1979).

Although the observation of time on task has been considered attentiveness and has been the forefront of research in the past ten years (Berliner, 1979; P. L. Peterson & Swing, 1982, Rosenshine, 1979; Stallings, 1980), students' reports of their own attentiveness and cognitive processes were demonstrated to be more valid indicators of achievement (P. L. Peterson, Swing, Stark & Waas, 1984). By using stimulated recall after videotaped lessons, students reported that lesson relevant thinking only occurred 25 to 60% of lesson time (Edwards & Marland, 1984) and that many stimuli that teachers intended to be instructional were not perceived by students as such (Winne & Marx, 1982). This implies that for instruction to be effective, many students may need very explicit directions concerning what they are supposed to learn as well as instructional devices that will focus their attention on that which is to be learned.

In the context of the classroom setting, textbook writers and researchers have utilized various techniques to focus attention during instruction in order to assist learners in acquiring knowledge. When questions were given to students prior to the instructional materials, the "forward shaping" cues preconditioned students to convergently focus on finding only those answers germane to the questions that preceded the text (Anderson, 1970; Rothkopf, 1970; J. T. Wilson & Koran, 1976). It has been demonstrated that questions placed before text produced greater learning of the intended objectives while depressing the acquisition of incidental learning (Frase, 1968; J. T. Wilson, 1973). Students were also found to spend more time on information directed by inserted questions in text and less time on non-questioned portions of the text (Holliday, 1981; Reynolds, 1979).

Cues such as advance organizers and behavioral objectives were investigated by Borer (1981) in a study of reading comprehension involving 96 sixth graders.

Those students with high selective attention in the experimental groups were given either the advance organizers, behavioral objectives, or both, and outperformed the students in the control group who were not provided any cues. The advance organizers and objectives alerted students' attention and provided them with a framework for the text that followed. Working with another type of cue, Dansereau (1982a) found that students who were provided with headings in text performed significantly better than those whose text did not contain these aids. The headings provided an outline about which the learners could organize and focus their attention on the information presented in the text. These lines of research suggest that attention cues in the form of questions, advance organizers, objectives, and headings, can help focus attention and produce more learning. It is from these types of studies that the objectives previously outlined were derived and the subsequent treatments developed for this study.

There is research that contradicts the notion that cues are more helpful than no cues. The differences in how students perceived what was expected of them was also shown to have a bearing upon achievement. Groups that were required to generate their own headings for textual material outperformed groups given headings by the researcher (Dansereau, 1982b). This experience required the students in the generative group to actively process the information and classify it into categories that were meaningful to them. Some no question groups also achieved significantly more than question-cued groups during textbook study (Holliday, 1981; Reidbord, 1979). This "no question condition" is similar to the "backward review" activity required of students when questions were utilized after exposure to the materials (Rickards, 1979; J. T. Wilson & Koran, 1976). In those situations, the learners were not only attentive to all of the material, but they also processed the information in a divergent way by using their own strategies rather than one provided for them. There is a need to extend this type research from the classroom to other types of settings (such as informal settings as described by J. J. Koran, Longino, & Shafer, 1983) in order to investigate the mediating effects of ability, both with and without cues that focus students' attention, upon achievement in those settings.

Learning in Informal Settings

Informal learning takes place in settings outside of the traditional classroom such as in homes, zoos, museums, nature centers and through participation in various organizations. Learners of all ages have been found to choose the content, materials, and the time they wish to spend in a specific informal environment (J. J. Koran & Longino, 1982); they were neither given tests nor held accountable for what they had observed which is in sharp contrast to that found by students in formal classrooms.

Shettel et al. (1968) studied the educational role of museums by examining the visitor variables, exhibit variables, and exhibit effectiveness. He worked with mock-up designs of future museum displays and determined that in order for an exhibit to attract and maintain the viewers' attention, the exhibit had to communicate its message to a very diverse group of people. Cronje (1980) has since substantiated the conclusion that the modes of communication had to be presented with clarity to meet the needs of various visitors. Whether there was a necessity to provide attention cues to all subjects for the the purpose of communicating the exhibit's message to them was another question investigated in this study.

Audio devices and a variety of interactive means have been the focus of museum studies that have attempted to gain the attention of museum visitors. Audio mechanisms were found to increase children's attention to exhibits (Abler, 1968) and similar results were found in adult museum goers (Screven, 1974). The audio adjuncts, with a travelogue type discourse, focused attention to particular features of the exhibits. Screven's (1974) use of pretests, behavioral objectives and electronic punchboards (for questions and immediate feedback to visitors in a museum setting) had positive effects on cognitive outcomes. These interactive aids attracted and held the attention of the viewers in a museum where visitors could easily be distracted by the many stimuli found in such a setting.

A less expensive method to focus attention in a museum setting was reported with the use of programmed cards (DeWaard, Jagmin, Maisto, & McNamara, 1974). Those visitors who viewed an exhibit with the advantage of the programmed cards learned more than those who did not have their attention directed to significant aspects of the exhibit by cards. In a study (J. J. Koran, Lehman, Shafer, & Koran, 1983) utilizing an existing panel that consolidated information about a Florida cave, the panel was used both as a pre-attentional and as a post-attentional device. One experimental group of high school students viewed the panel before walking through the Florida cave exhibit; a second group viewed the panel after exiting the cave. Both groups outperformed the control group that was not given the panel to view as an attention cue. All of the above methods for focusing and holding attention of museum visitors were congruent with cognitive learning theories (Bransford, 1979; Gagné, 1973) and have shed light on what further steps might be taken to simplify and amplify attention cues for those requiring such cues in order to learn optimally.

Researchers have suggested that museums, science centers, and field trip experiences have great potential as adjuncts to school learning (Baker & Sellar, 1983; Kimche, 1978; J. J. Koran & Shafer, 1982; Silver, 1983), but little data are available to suggest precisely what takes place in these settings that is different from a regular classroom setting. It has been shown, however, that cueing students to the setting prior to a field trip increased learning (Falk & Balling, 1980; Falk, Martin, & Balling, 1978; Sneider, Eason, & Friedman, 1979). Students who had become familiar with the setting were not distracted by such a stimulus-rich experience; therefore, their focus was on the designated point of interest. Similarly, Gennaro (1981) evaluated the educational outcome of a museum visit using previsit materials. Eighth grade students who were given the previsit instructional materials learned more than their counterparts who were not given such materials. Although both groups were given classroom instruction, the group that was oriented to the museum visit outperformed the control group on content.

In an investigation by Wright (1980) of sixth graders reviewing the human body, one group had a multisensory hands-on review in a museum and the other group a nonhands-on classroom review session on the same information. The museum review group demonstrated superior comprehension and application of both knowledge and concepts. The author concluded that the unit of information that preceded the hands-on museum review served to orient this group, heighten their attention, and accounted for their significantly superior achievement. This is consistent with the previous research reviewed on attention and learning.

In a study by Linn (1980) a "free choice" classroom environment was set up to approximate that of a museum or field trip. Results suggested that free choice, even within the classroom, was effective only after students had received some guidance toward the goals of instruction. P. M. Smith (1981) similarly measured the effectiveness of a museum outreach van versus a guided tour in a museum. The outreach program, that brought museum materials into the familiarity of the classroom, produced higher scores than the regular museum visit. The above studies give support to the advantageous use of pre-instructional orientation before an informal learning experience both to focus attention and to reduce the "novelty interference" phenomenon.

Not all types of field trips have been found to be equally beneficial to students even if consideration has been given to orientation. In a comparison of a single process-oriented field trip, a single content-oriented field trip, and regular classroom instruction on the same material, Wiley (1984) reported that process-orientation was the dominant factor in the development of concrete concepts that persisted over time. After proper instructional orientation and a means of focusing student attention, the single most important source for producing maximal student learning is the students' opportunity to actively explore and manipulate hands-on type materials. It is with this in mind that achievement was investigated in regard to the subjects' manipulative curiosity of objects presented in this study.

Curiosity and Active Exploration

Curiosity is a means by which children learn more about their world. Although the nature of curiosity has been the focus of researchers' interest for over fifty years, only recently have studies emerged concerning subjects' behavior in the school and museum areas.

Berlyne (1954, 1966) explained curiosity as that drive of individuals which could be reduced only by physical or mental investigation of novel, incongrous stimuli. A perceived discrepancy between the individuals' experiences and what they expected led them to reduce the discrepancy (Charlesworth, 1964). In 1978, Berlyne redefined curiosity as an attribute that existed in two forms: (1) perceptual, which activated uncertainty-relieving perceptions, and (2) epistemic, which activated the quest for knowledge. Evidence suggests that this tendency to activate curiosity has been found to occur in children at various ages with no extrinsic reward given. Curiosity provided its own intrinsic reward in the form of reducing the uncertainty or ambiguity of a particular situation for those subjects (Day, 1982; Klausmeier, 1975; Morris, 1976; Vidler, 1977).

Curiosity is said to be exhibited when an individual scans the environment for novelty, approaches a novel, incongrous, or complex object or event, interacts with it, and persists in this behavior (Cantor & Cantor, 1966; Henderson, 1980; Maw & Maw, 1964). The sensory motor responses to these objects or discrepant events have been classified into a heirarchy of levels: (1) an individual approaches an object without touching it; (2) an individual approaches and manipulates the object; and (3) an individual approaches, manipulates, and reorganizes an object or its parts, or causes them to interact with each other or with the environment (R. W. Peterson, 1979; R. W. Peterson & Lowery, 1972).

With a sample of 120 kindergarten, second, fourth, and sixth graders, R. W. Peterson & Lowery (1972) placed children individually into a novel environment and observed them unobtrusively. The exploratory behaviors of the subjects toward specific objects were rated numerically using the above hierarchy. The amount of curiosity expressed through exploratory behavior was not significantly different for the various age groups, but those with higher motor activity usually asked fewer unsolicited questions. In addition, R. W. Peterson (1975), discovered that the presence of an adult in a contrived situation had a negative effect on the students' expression of curiosity. Since teachers' ratings of students' levels of curiosity have usually been based upon questions that students ask, while motor activity has been considered disruptive behavior in the classroom, many highly curious students have neither been identified nor encouraged to develop their curiosity. When, however, teachers expressed favorable attitudes toward students' expression of curiosity, students showed significantly higher levels of various curiosity behaviors including sensory motor and verbal activities (Elias & Elias, 1978; Henderson, 1980).

Interactive, hands-on science experiences have become enjoyable to visitors and have contributed to the success and popularity of science museums and learning centers (Carlisle, 1985). Researchers (J. J. Koran, Morrison, Lehman, Koran, & Gandara, 1984) demonstrated that 58.5% of those who entered a specific area of the Florida State Museum went to the section where hands-on materials were located in drawers. This number significantly increased to 82.3% when objects were readily available and subjects could manipulate them freely. The attraction of participatory exhibits was also evidenced by the endeavors of researchers at the San Francisco Exploratorium (Oppenheimer, 1972; Oppenheimer & Cole, 1974). Dynamic, or hands-on, exhibits were prevalent there and permitted visitors not only to look at, but also to touch, alter, and to interact with the exhibits. Many of the exhibits challenged the visitors to solve and work through problems. These types of hands-on activites are reminiscent of the process-oriented science curricula of the 1960s. Activity based and multisensory experiences aided the learning of students, particularly those of low ability and those who needed concrete examples in order to learn and to remember (Bredderman, 1982; Mechling & Oliver, 1983; Wiley, 1984). However, there are little data on how curiosity and hands-on experiences directly affect learning in the museum.

Rather than to describe curiosity as a unitary construct of motor activities, Kreitler et al. (1975)

described curiosity as a group of traits. The following were the major three: (1) perceptual curiosity--that of perceiving displays of materials or objects, (2) manipulative curiosity--that of hands-on activities, and (3) conceptual curiosity--that of an individual asking questions about the object or event as a function of higher cognition. Hence, students' preferred styles of expressing curiosity have been shown to exist as exploratory behaviors, verbal behaviors (R. W. Peterson & Lowery, 1972), tolerance for ambiguity (Maw & Magoon, 1971; Maw & Maw, 1972), active or passive cognitive exploration (Hazen, 1982; Kreitler et al., 1975), or some combination of these. Due to the diverse ways that curiosity may be exhibited, an examination of curiosity should encompass exploratory sensory motor activities, written responses to novel situations, and unsolicited questions.

Although few studies have addressed the value of curiosity in facilitating learning, there have been related studies. Studies that concern the role of curiosity in arousing conflict and the internal cognitive process (J. J. Koran & Longino, 1982; Rowe, 1978; Vidler, 1980a), in encouraging inquiry (Tamir, 1978), and in fostering motivation (Gensley, 1971, 1977; Jones, 1980) indirectly imply that curiosity may be the factor that stimulates learning.

There is further evidence that curiosity is linked to cognitive outcomes. In an investigation of 121 undergraduates, Vidler (1980b) reported that curiosity was related to both performance and class attendance with moderate significant relationships. Controversy, compared with no controversy, in groups of fifth and sixth graders, indicated that controversy led to more epistemic curiosity and higher achievement (Lowry & Johnson, 1981). In Garcia's (1978) dissertation that involved 227 children of poverty families, a significant relationship was found between curiosity and school performance of second and third graders although none was found for first grade children. These studies provide some insight into the positive relationship of high curiosity students with high performance and suggest that more extensive experimental research should be undertaken to explore the role of curiosity in achievement, particularly in an informal learning setting where curiosity can be nurtured.

Knowledge of the Criterion Task

Knowledge of the criterion task and the concomitant use of different study techniques and test strategies have been found to be specific to the type of assessment given as evidenced by the study that follows. Those who prepared for a multiple choice test on textual material reported 30% rereading of the text; those who prepared for an essay examination reported a 52% rereading rate. After the administration of a multiple choice examination, subjects responded that they used 22% multiple strategies compared to subjects who reported that they used 40% multiple strategies after an essay test (Alverman & Ratekin, 1982). Students responded to performance expectation as they perceived it rather than to what was actually stated by the teacher (F. R. Smith & Feathers, 1983). This was a result of the students' experiences with particular teachers' testing methods and/or threats of testing that were not carried out.

The type of instructional materials presented to the learner in relation to the type of examination given also affected performance. Subjects receiving pictorial cues along with prose instruction demonstrated better pictorial recall than those who did not receive such cues (Matthews, 1980); when the students perceived a mismatch between instruction and testing, achievement scores were lower. In contrast, prior knowledge of the specific criterion task has been found to enhance performance and those who knew they were to be tested outperformed those who did not possess this information (Wong, Wong, & Lemare, 1982). These findings on the knowledge of a test versus no awareness that an examination was forthcoming and the effect of instructional cues upon student achievement give the impetus to further research in an informal setting, such as a museum, in order to define the types of students who would perform better under each circumstance (knowledge of a test versus absence of that knowledge) and to extend Salomon's (1984) conception of invested mental effort to the informal setting.

Amount of Invested Mental Effort

Researchers have considered effort an important factor in achievement, but have differed in their attempts to describe its nature. Effort has been equated with such descriptors as motivation (Atkinson, 1966), as the capacity to respond to a stimulus (Kahneman, 1973), as one's expectant level of efficacy (Bandura, 1977), as persistence and time on task (I. Brown & Inouye, 1978; Rosenshine, 1979; Stallings, 1980), and as that which is spurred on by continued success (Revelle & Michaels, 1976). This last representation is supported by a study of 80 fifth and sixth graders (Ames & Ames, 1981) who knew of their success with previous tasks they performed individually and attributed their future success to the effort they devoted to the new task.

The amount of invested mental effort (AIME) has been coined by Salomon (1983) as a more detailed descriptor to specify the "number of nonautomatic mental elaborations applied to material" (p. 44). The AIME expended depends largely on the subject's perception of the task. This factor has been termed the perceived demand characteristic (PDC). If the task was perceived as difficult or unfamiliar, the perceived demand characteristic was high. This in turn increased the student's use of cognitive strategies and mental elaborations of the materials with a high level of mental effort. Similarly, if a task was perceived as easy or familiar, even if the stimulus was complex or ambiguous, less mental effort was invested and the subjects relied upon their automatic cognitive responses and minimal, if any, mental elaborations were applied to the task.

In Salomon's (1984) study of 124 sixth graders while learning the same information from television versus text, the amount of invested mental effort was determined by the number of inferences the students made and by self-reports. Students perceived television as more realistic and easy, thereby they invested less mental effort; students perceived print as difficult which required them to invest more mental effort. As a result, those who expended more mental effort were able to make better and more numerous inferences about the material and also reported they had invested more effort.

In this same study, Salomon (1984) discussed another factor related to AIME--the learners' perceived self-efficacy (PSE). If students perceived themselves to be more efficacious, they were likely to invest sustained effort and persist in the task they perceived as difficult. Both the perceptions of demand characteristics and of self-efficacy were theorized to affect the amount of invested mental effort for a particular task, or context of material. The amount of mental effort expended, in turn, influenced learning.

In addition to assessing the difficulty of a task, students decided when to invest more mental effort according to what directions were given, to their perception of the task's worth, how much attention to give to it, how to learn it, and how deeply to learn it (Salomon, 1983). Hence, any variable that could influence these perceptions could affect the amount of mental effort learners would be willing to invest. With this consideration, the subjects' knowledge of an impending test versus no knowledge of an exam was an attempt to differentially affect the amount of invested mental effort expended by the subjects in this study of a museum exhibit.

Aptitude Treatment Interactions

A multitude of educational research studies in the past have sought the one best instructional method for all students. When the mean of the subjects' scores in Group A was higher than the mean of those in Group B, treatment A was proclaimed as the panacea for all learners. Perhaps the treatment would be advantageous for subjects who scored at the mean, but not for those whose scores were widely scattered in the distribution. This traditional research did not take into account the differences in students' emotional status, prior achievement, personality traits, learning styles, or mental abilities.

Previous attempts to individualize instruction included streaming students by tracks (B. J. Wilson & Schmits, 1978) and changing the rate of instruction in the form of mastery learning (Block & Anderson, 1975); however these methods did not produce encouraging results. In order to maximize the learning potential of each student and to personalize education, it is most important to match the method of instruction to the subject's individual learning characteristics (Messick, 1979; Tobias, 1982).

A recent type of research suggests how learner characteristics differentially modify treatment effects (Cronbach, 1975; Cronbach & Snow, 1977; M. L. Koran &

Koran, 1980; M. L. Koran & Koran, 1984); this research is termed aptitude treatment interaction (ATI) research. The principle of ATI studies is that all students are influenced by the educational environment--the stimuli presented by instruction as well as the learners' perceptions of that environment mediated by their individual differences (Berliner, 1983). Thus, no one educational environment is best suited for the optimal learning of all students. Rather, different individuals prosper in different environments that best match their learning characteristics or aptitudes.

Cronbach and Snow (1977) defined an aptitude as any characteristic of the learner that functions selectively with respect to learning--either facilitating or hindering learning from a particular type of instruction. A treatment was specified as any type of instructional method to which a learner was exposed with variations in structure, pacing, style, modality, instructor, or learning setting. An interaction occurs when two or more treatments are designed to reach the same educational goal, but one treatment is significantly better for one type of learner, whereas a different treatment is superior for another type of student. The aptitude must be measured for each subject prior to treatment so that it may be determined which instructional conditions would best benefit each learner at his level of that aptitude.

Cronbach and Snow (1977) cited many studies in which individual differences in aptitudes have been found to impact learning. They reported that the aptitude of general ability interacted more often than any specific type of ability. Treatments that involved discovery learning or that required the subjects to process information on their own benefited high ability students while hindering those of low ability. Students having a high general or verbal ability have been found to be more capable of processing greater amounts of sensory data (Allen, 1975).

Examples of interaction studies that favored lower general ability students were those that provided instructional support (Tobias, 1982). Some of these included the use of pictorial adjuncts to text (Chute, 1979; Dwyer, 1972; Holliday, Brunner, & Donais, 1977; M. L. Koran & Koran, 1980), flow diagrams (Holliday, et al., 1977), inserted questions in text (Holliday, 1981; Reynolds, 1979; J. T. Wilson, 1973) and headings in text (Dansereau, 1982a). They provided lower ability students with needed cues, attention devices, and explicit rules to remedy certain learning deficits (A. L. Brown, Campione, & Day, 1981). Other studies showed that low achieving students benefited from structure and direction (Ebmeier, 1978). Advance organizers were particularly advantageous to low ability learners; they helped to reduce the demand on these students' ability to apply their own cognitive processes to systematize the information from text. These aids alerted their attention and provided them with a framework for the text that followed (Borer, 1981; J. J. Koran & Koran, 1973). The notion of using an advance organizer in a museum was implemented by Stankiewicz (1984). The advance organizer provided a schema about which the learners could better focus their attention and organize the information they gleaned from the museum exhibit. Again, low ability students benefited from an advance organizer while high ability learners were constrained in their thinking and learning processes.

High ability subjects have been found to perform best in an environment that is task-oriented and that leaves much of the cognitive processing, organization, and intrepretation to the learner (Cronbach & Snow, 1977; Ebmeier, 1978; J. J. Koran & Koran, 1973). In the studies where low ability learners profited, high ability learners did not. Treatments that capitalized on the well developed cognitive abilities of learners who preferred to use their own strategies for learning, organizing, and remembering were beneficial to high ability learners (Ebmeier, 1978; Galpert-Paris, 1979; Holliday, 1981; Reidbord, 1979). All of the above ATI studies produced interactions when general ability was the measured aptitude. Moreover, Cronbach and Snow (1977) suggested that the aptitude of general ability be included in all ATI studies.

Messick (1979) discussed motivation in regard to curiosity as one of the many non-cognitive personal characteristics posed as educationally relevant. He suggested that high levels of curiosity would induce optimal levels of conceptual conflict and novelty, thereby affecting the learning process. The effect of curiosity upon achievement was investigated in a study that included 35 seventh and 46 eighth graders (J. J. Koran, Koran, Fire, & Morrison, 1985). The interaction of Curiosity Level x Treatment (inductive vs. deductive) x Grade of the Student approached significance (F = 2.22, p = .06). While this study had only 81 subjects with complete data, or 11-13 per treatment per grade, curiosity may well have been found a factor in achievement if a larger similar sample were used as suggested by Cronbach and Snow (1977).

This analysis suggests that aptitude measures of general ability and of curiosity may be worthy of investigation in a museum study. An informal learning setting, such as the museum, may provide subjects the opportunity to interact with potentially educational science materials. The strategies subjects possess and will employ might interact with the attention cues given, with their curiosity levels, and with the mannner in which they will perceive the task.

Summary

The following were the major points derived from the literature reviewed in this chapter and led to the hypotheses to be tested:

1. Attention is necessary for learning to take place and many students require cues and focusing devices to hold their attention.
2. Maximal learning is produced when students have the opportunity to manipulate science materials.
3. Subjects' willingness to manipulate hands-on materials increases significantly when the objects are available; thus they increase their motor curiosity behaviors.
4. There is evidence that curiosity is related to cognitive outcomes, although few studies have addressed the direct value of curiosity in facilitating learning.
5. The amount of invested mental effort (AIME) depends on the perceived demand characteristic (PDC) of the task and the subject's perceived self-efficacy (PSE) with the task.
6. Prior knowledge of a specific criterion task has been found to affect performance.

7. Any variable such as knowledge of the criterion task may influence the subject's perception of the task, thereby influencing the amount of invested mental effort.
8. Learner characteristics may interact with the types of cues given to them prior to viewing a museum exhibit.

Hypotheses

Based upon the aforementioned research, the following hypotheses were formulated: (All hypotheses were tested at alpha = .05).

1. Subjects receiving treatment cards with attention focusing questions about a museum exhibit will perform significantly better on a written criterion measure than subjects receiving treatment cards with no attention cues.
2. Subjects receiving treatment cards with cues that refer to a forthcoming achievement test about an exhibit will perform significantly better on the criterion measure than subjects receiving treatments cards with no reference to a test.
3. Subjects receiving treatment cards with test cues will be influenced to invest more mental effort and will perform significantly better

on the inference portion of the criterion than subjects not receiving these cues.

4. Subjects who demonstrate high levels of written curiosity before approaching an exhibit will perform significantly better on both the psychomotor and written curiosity measures after their interaction with the exhibit than subjects who have low levels of written curiosity.
5. There will be a differential relationship between criterion performance and aptitudes of subjects as measured by the vocabulary, curiosity, and invested mental effort measures.

CHAPTER III
EXPERIMENTAL PROCEDURES

Subjects

Sixth grade students from one rural north central Florida middle school participated in this study during the second semester of school. All subjects had the same teacher for science class and had been exposed to the same science curriculum during the school year. The group of subjects included 75 male (58%) and 54 female (42%) students of which 69 (53%) were black and 60 (47%) were white. A distribution of the experimental subjects by treatment, sex, and race appears in Table 1. The 129 subjects from five sections of general science completed the aptitude measures of vocabulary, curiosity, and invested mental effort, followed the instructions given on the treatment cards, and took the posttests. Data from these 129 subjects were used in all subsequent analyses. Absence from school prevented an additional 22 subjects from completing the experiment.

General Procedures

One week prior to the experiment, the aptitude measures of verbal ability, written general curiosity, and written science curiosity were obtained for all

Table 1
Distribution of Subjects by Treatment, Sex, and Race

	Male		Female		
Treatment	Black	White	Black	White	Total
1	10	6	6	9	31
2	12	9	3	9	31
3	10	11	8	5	34
4	11	6	9	5	33
Total	43	32	26	28	129

subjects. During the week of the experiment, which was carried out during regular school hours, one section per day was isolated in the science classroom, and the remaining sections spent the day in four other classrooms with teachers who utilized the time to teach these students their other subjects. The students were asked not to discuss what they experienced with their peers. This was monitored by the classroom science teacher, other teachers, and by the three persons involved in administering the experiment.

Subjects within the first section were brought to the treatment room one at a time and randomly assigned to one of the four experimental treatments. Upon entering the treatment room each student was read the section of directions by an experimenter, was instructed to read the remainder of the treatment card assigned, to follow the directions, and to let the experimenter know when he/she was finished. During a maximum stay of 10 minutes in the vicinity of the shell museum exhibit, each subject was observed and timed for his/her psychomotor curiosity or hands-on exploration.

At the end of 10 minutes (or less if the subject said he/she was finished) the subject went to a second area. The student was given a packet of tests that included the measure of the amount of invested mental effort (AIME), a criterion measure of factual knowledge, a criterion measure that required inferences, a posttest of general curiosity and a posttest of science curiosity. The measure of the amount of invested mental effort (AIME) was given prior to all other measures so that the subjects' reports of AIME would apply to the exhibit and not to the other tests. Subjects proceeded at their own pace and could ask clarification or word meaning questions of a second experimenter.

Subjects were then directed to a third area where they could talk and ask questions that they still had about the exhibit with a third experimenter. This conversation was tape recorded and later coded for unsolicited questions that pertained to curiosity and for statements that related to the amount of effort invested by the subject. The same procedure was followed for all subjects in the first section on the same day. The other four sections of subjects were processed on four subsequent days in the same fashion.

The Design

The modified posttest only design was used to test the hypotheses (Table 2). All four experimental groups received the corresponding instruction and were given an immediate posttest. This design permitted the evaluation of the effects that each independent variable (attention cues versus no attention cues, knowledge of an impending test versus absence of this knowledge,

Table 2
Experimental Design

Instructional Cards	Test Cues Given (T)	Test Cues Not Given (NT)
Attention Cues in the form of questions	A-T	A-NT
No Attention Cues	NA-T	NA-NT

level of written curiosity, amount of psychomotor curiosity, amount of invested mental effort, and verbal ability) had upon the dependent variables (criterion measures of knowledge and inferences, and curiosity). In addition to main effects, the design permitted investigation of Aptitude x Treatment interactions.

Treatments

The following is a summary of instructions that were placed on 5" x 8" typewritten cards and received by students in the four treatment conditions.

1. Subjects in treatment one were given attention cues in the form of questions about salient features of the shells in the exhibit. A reference to a test was underlined in red pencil and subjects were instructed to learn as much as possible for the test.
2. Subjects in treatment two were given the same attention cues as in treatment one, but no reference to a test was given nor were subjects instructed to learn as much as possible.
3. Subjects in treatment three were not given questions as attention cues, but a reference to a test was underlined in red pencil and subjects were instructed to learn as much as possible for the test.

4. Subjects in treatment four were not given questions as attention cues, not cued for a test, nor instructed to learn as much as possible.

All subjects were encouraged to touch the shells and to return them to their respective places in the exhibit. The time frame of 10 minutes was indicated on all treatment cards.

Instructional Materials

Each subject received one of four typed instructional cards. Each card contained a short section of directions which was read aloud to the subject; the subject was instructed to read the rest of the card silently. Two treatment cards included questions pertinent to the 41 shells in the exhibit and two cards had no such questions. These questions were designed to provide both attention cues and a schema about which students could organize information they gleaned from the exhibit. The cards also varied on whether or not the subject was alerted to a forthcoming test. Four middle school science teachers examined the materials and found them to be appropriate for sixth grade students.

Each treatment card contained information on only one side of the 5" x 8" card. The section on directions consisted of four sentences (in the no test cue conditions) or six sentences (in the treatments that cued for a test). A section defining univalve, bivalve, and shell hinge was worded the same in all treatments, but was categorized differently. In the no test cue conditions, the category was "Some Information"; in the treatments that cued for a test, the category was "Some Clues." A section appeared with identical questions that served as attention cues. When the questions were in conjunction with the test cue treatments, they were labeled "Some More Clues," in the no test cue conditions, the heading was "Some Things to Think About." Students carried the assigned treatment card with them during the entire period they were in the vicinity of the shell exhibit so that they could refer to the questions or to any other part of the treatment as needed.

The initial written materials were field tested with a group of 32 sixth graders in another rural middle school. The information gained from the field test was used to revise the materials in order to increase their clarity and ensure that all students could read them easily. A Fry (1968) readability estimate of the treatment cards indicated an approximate reading level of the third grade, fifth month. Examples of the written treatment cards can be found in Appendix A and a photograph of the exhibit in Appendix B.

Measures

Aptitudes

Subjects were given aptitude measures of verbal ability, general curiosity, and science curiosity prior to the treatment. These were given based on the possibility that they could affect the learning process during the time the subjects viewed the shell exhibit. The verbal ability measure (Vocabulary-1) was taken from the Kit of Reference Tests for Cognitive Factors (French, Ekstrom, & Price, 1963). It consisted of 2 parts of 18 words each which the students had to define by choosing 1 of 4 meanings; each part was timed for 4 minutes. The reliability coefficient as 0.69. Since this measure had its lower limit at the sixth grade level and because students seemed to have difficulty with it, the scores were correlated with other measures available from school records. This vocabulary measure significantly correlated with IQ ($r = 0.40$, $p = 0.0001$) and with reading scores taken at the beginning of the school year ($r = 0.43$, $p = 0.0001$). Since there were missing values for new students of school available scores, they were not used in the analyses.

General curiosity was measured by an adaptation of the Children's Reactive Curiosity Scale (Penney & McCann, 1964). The original test, composed of 90 true-false items and 10 "lie" items, had a 2 week test-retest reliability of 0.75 for sixth graders. It had a low discriminate validity with IQ (0.06 for girls and 0.24 for boys) demonstrating that curiosity is a trait different from, and independent of, IQ. The test developers also reported a significant positive correlation between reactive curiosity and three measures of the Guilford's Unusual Uses Test (Guilford, 1956) indicating criterion validity. Content validity was established by a group of upper elementary school teachers. Only the items identified by the test developers as those which significantly discriminated extreme scorers and the 10 "lie" items were reworded and adapted for this study. The questions used in this study to determine general curiosity can be found in Appendix C.

The aptitude of science curiosity was measured by an adaption of the Children's Science Curiosity Scale (Harty & Beall, 1984). This instrument had an alpha coefficient of internal consistency of 0.85 for its Likert-type scale items. Construct validity was established with a Scott's coefficient of interrater reliability of 0.77 among eight judges. Predictive validity was determined by correlating the levels of science curiosity of another group of fifth graders to their letter grades in science three months later ($r = 0.30$, $p < 0.002$). Examples of those questions used in this study can be found in Appendix D.

The amount of invested mental effort (AIME) was measured immediately following the treatment and prior to all other posttest measures so that the AIME measured would be that which applied to the exhibit and not to the criterion tests. The questions given were those suggested by Salomon (1983) involving the subject's perception of the task as to difficulty, worth of learning, how to learn it, and how deeply to learn it. Each question had four choices which had scoring gradations from 1 point to 4 points with a total possible score of 24. The Kuder-Richardson 21 reliability was 0.38. The questions used to determine the AIME can be found in Appendix E.

Psychomotor curiosity was timed with a stopwatch by an observer while the subject was in the vicinity of the shell exhibit. The student's manipulation of the objects in the exhibit was psychomotor as defined by several researchers (Cantor & Cantor, 1966; Henderson, 1980; Maw & Maw, 1964; R. W. Peterson, 1979; R. W. Peterson & Lowery, 1972).

Posttests

All subjects received a 20-item written criterion test as part of the packet given to them immediately following their perusal and/or study of the shell exhibit. One portion of the test consisted of 10 factual questions to which each subject had to supply single word answer. The second portion contained 6 multiple choice items (with 5 alternatives) which required the subjects to make inferences about what they had viewed in the exhibit. Four additional inferential items required the students to draw (1) the size and shape of an animal they thought lived in a particular shell, (2) how a baby animal would appear in its shell, (3) how the same animal would appear as a one year old, and (4) again as a five year old, with growth changes. The Kuder-Richardson 21 reliability coefficients were 0.60 for the knowledge items, and 0.57 for the inference items. Content validity was established by four judges. A readability estimate (Fry, 1968) indicated an approximate reading level of the fourth grade. This posttest appears in Appendix F.

The general curiosity posttest was the same as that described above under aptitudes. The curiosity posttest pertaining to science was an adaptation of Leherissey's (1971) which had a reliability coefficient of 0.89. It was designed to determine a subject's curiosity after interaction with a curiosity evoking stimulus. The wording of this posttest was amended to reflect a stimulus as that of a shell museum exhibit. The posttest appears in Appendix G. The reliability coefficients of all measures used in this study are presented in Table 3; their correlations appear in Appendix H.

Table 3
Reliabilities of Measures Used

Measure	Reliability
Aptitudes	
Vocabulary	0.69
General curiosity	0.75
Science curiosity	0.85
AIME	0.38
Posttests	
Factual knowledge	0.60
Inferential ability	0.57
General curiosity	0.75
Science curiosity	0.89

CHAPTER IV
RESULTS

The primary purposes of this study were

1. To investigate the differences in learner achievement when the treatments varied in (a) the presence or absence of attention focusing questions, and (b) the presence or absence of test cues;
2. To examine the relationship between the students' initial curiosity levels to their curiosity levels after a novel, hands-on informal learning experience;
3. To investigate the interaction of each of the four aptitudes (verbal ability, general curiosity, science curiosity, and the amount of effort invested in the learning experience) with the various treatments.

The results of the analyses of the instructional treatment main effects will be followed by the analyses of the Aptitude x Treatment effects. All analyses were computed using the University of Florida Statistical Programs Library and the SAS Language Library.

Variables

All four treatment cards included a similar section of procedural directions, with test cues indicated in two of the four treatments. A second section included definitions relevant to the shell exhibit, and a third section contained attention cues in two of the four treatment conditions.

Data were collected for all subjects on measures of verbal ability, pretest written general curiosity, pretest written science curiosity, and the amount of invested mental effort. Descriptive statistics for these variables are reported in Table 4.

Scores were obtained for the subjects in each treatment group on the posttest composed of 20 questions. The scores were subsequently divided into a score for 10 factual items (constructed responses) and another for 10 inferential items (6 forced choice items plus 4 items that required the students to draw what they had deduced from the exhibit). Additionally, the length of time that students spent in the vicinity of the exhibit was recorded. These cell frequencies, means, and standard deviations are reported in Table 5.

Data were also obtained for each subject on posttest written general curiosity, science curiosity, and the amount of time each subject spent in exploratory

Table 4
Aptitude Data

Treatment[a]	Verbal Ability			Pretest General Curiosity			Pretest Science Curiosity			Invested Effort		
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
A-T	31	11.53	3.59	31	9.62	3.34	31	17.34	6.64	31	16.37	1.83
A-NT	31	12.23	3.91	31	9.67	2.62	31	17.07	6.46	31	16.81	3.53
NA-T	34	11.35	3.42	34	10.36	2.49	34	18.00	7.21	34	17.56	2.15
NA-NT	33	11.09	2.98	33	10.68	1.94	33	19.00	5.02	33	16.42	2.77

[a] A-T = attention cues given, test cues given;
A-NT = attention cues given, no test cues given;
NA-T = no attention cues given, test cues given;
NA-NT = neither attention cues nor test cues given.

Table 5
Posttest Data

Treatment[a]	Factual Items			Inferential Items			Total Posttest			Viewing Time		
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
A-T	31	6.87	2.29	31	2.40	1.89	31	9.27	3.47	31	6.22	3.48
A-NT	31	6.52	1.84	31	2.55	1.55	31	9.07	2.68	31	6.38	3.09
NA-T	34	7.03	2.44	34	3.44	2.65	34	10.18	3.64	34	6.13	2.79
NA-NT	33	6.91	2.07	33	2.67	1.59	33	9.58	3.00	33	7.55	2.73

[a] A-T = attention cues given, test cues given;
A-NT = attention cues given, no test cues given;
NA-T = no attention cues given, test cues given;
NA-NT = neither attention cues nor test cues given.

behavior (psychomotor curiosity). Descriptive statistics for these variables are reported in Table 6. Written general curiosity and science curiosity change scores appear in Table 7. Since change scores are unstable and unreliable, they are presented only for visual inspection and interest.

Instructional Treatment Main Effects

The following hypotheses were of major concern relative to instructional treatment main effects.

1. Subjects receiving treatment cards with attention focusing questions about the museum exhibit will perform significantly better on a written criterion measure than subjects receiving treatment cards with no attention cues.
2. Subjects receiving treatment cards with cues that refer to a forthcoming achievement test about the museum exhibit will perform significantly better on the criterion measure than subjects receiving treatment cards with no reference to a test.

In order to investigate main effects for attention cues and test cues, a regression equation was used containing both attention cues and test cues as components of the regression model. Dependent measures

Table 6
Posttest Curiosity Data

Treatment[a]	Posttest General Curiosity			Posttest Science Curiosity			Psychomotor Curiosity[b]		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
A-T	31	12.93	3.27	31	25.17	4.89	31	3.74	2.79
A-NT	31	14.23	2.79	31	25.16	5.58	31	3.80	3.09
NA-T	34	13.85	3.12	34	26.18	5.45	34	4.21	2.53
NA-NT	33	13.82	2.96	33	24.70	3.92	33	5.27	2.73

[a] A-T = attention cues given, test cues given;
A-NT = attention cues given, no test cues given;
NA-T = no attention cues given, test cues given;
Na-NT = neither attention cues nor test cues given.

[b] Reported in minutes of exploratory behavior.

Table 7
Curiosity Change Score Data

Treatment[a]	Change in General Curiosity					Change in Science Curiosity				
	n	Mean	SD	Minimum	Maximum	n	Mean	SD	Minimum	Maximum
A-T	31	+ 3.52	3.59	- 3.00	+ 12.00	31	+ 7.86	6.39	- 4.00	+ 21.00
A-NT	31	+ 4.66	2.83	- 2.00	+ 11.00	31	+ 8.17	7.13	- 8.00	+ 18.00
NA-T	34	+ 4.91	7.84	- 2.00	+ 46.00	34	+ 8.09	6.88	- 4.00	+ 26.00
NA-NT	33	+ 3.23	3.07	- 3.00	+ 8.00	33	+ 6.06	4.26	- 2.00	+ 13.00

[a] A-T = attention cues given, test cues given;
A-NT = attention cues given, no test cues given;
NA-T = no attention cues given, test cues given;
NA-NT = neither attention cues nor test cues given.

included the constructed factual items, the inferential items (forced choice items and items that required drawings), and the total posttest. Summary *F* values for these three models are presented in Table 8.

There were no significant main effects detected for either attention cues or test cues with any of the dependent measures.

Mental Effort and Inferences

The following hypothesis was of major concern relative to the amount of invested mental effort of the subjects and their ability to make inferences about the museum exhibit.

> Subjects receiving treatment cards with test cues will be influenced to invest more mental effort and will perform significantly better on the inference portion of the criterion measure than subjects not receiving these cues.

Analyses of variance were performed to determine the effect of (1) test cues versus no test cues upon the dependent variable of mental effort, (2) test cues versus no test cues upon the inference portion of the criterion test, and (3) the amount of mental effort upon the inferences made on the inference portion of the criterion test. Summary statistics for these analyses appear in Table 9.

Table 8
Summary Table of Dependent Variable Main Effects

Source	df	SS	MS	F
		Constructed factual items		
Attention Cues	1	3.12	3.12	0.67
Test Cues	1	2.76	2.76	0.59
Residual	126	584.32	4.64	
Total	128	590.20		
		Inferential items		
Attention Cues	1	6.12	6.12	1.91
Test Cues	1	1.91	1.91	0.60
Residual	126	404.78	3.21	
Total	128	412.81		
		Total Posttest		
Attention Cues	1	17.98	17.98	1.74
Test Cues	1	9.26	9.26	0.90
Residual	126	1302.57	10.34	
Total	128	1329.81		

Table 9
Analyses of Variance for Mental Effort and Inferences

Source	df	SS	MS	F
		Amount of Mental Effort		
Test Cues	1	6.02	6.02	0.84
Residual	67	477.71	7.13	
Total	68	483.73		
		Inferences		
Test Cues	1	13.8	13.8	4.06 *
Residual	67	232.8	3.4	
Total	68	246.6		
		Inferences		
Mental Effort	1	12.70	12.70	4.08 *
Residual	122	379.65	3.11	
Total	123	392.35		

* $p < .05$

When the amount of invested mental effort was the dependent variable, no test cue effect was detected, F (1, 67) = 0.84, $p > .05$. However, a significant difference in subjects' performance on the inference portion of the criterion measure was detected in those treatments containing test cues, $F(1, 67) = 4.06$, $p = .04$. With an error rate per family set at .05, a Bonferroni t test indicated that the nature of the difference in performance on the inference portion of the criterion measure was in favor of those subjects in the treatment that contained test cues only over those subjects in the treatment that contained both test cues and attention cues.

A significant mental effort effect was found, $F(1, 122) = 4.08$, $p = .039$, when the inference portion of the criterion test was the dependent measure. Subjects who invested more mental effort were able to make more and better inferences than those who invested less mental effort.

Curiosity

The following hypothesis was of major concern relative to curiosity.

> Subjects who demonstrate high levels of written curiosity before approaching the exhibit will perform significantly better on both the motor

> and written curiosity measures after their interaction with the exhibit than subjects who have low levels of written curiosity.

Analyses of variance were performed using psychomotor curiosity (time spent as hands-on exploratory behavior), written posttest general curiosity, and written posttest science curiosity as dependent measures. Summary statistics of these analyses appear in Table 10.

Although no significant pretest written science curiosity effect was detected when psychomotor curiosity was the dependent measure, it approached significance, $F(1, 122) = 3.37$, $p = .068$. The pretest written science curiosity variable was found to be significant, $F(1, 122) = 11.63$, $p = .0009$, when posttest written science curiosity was the dependent measure. A significant written general curiosity effect was also detected when the posttest written general curiosity was the dependent variable, $F(1, 121) = 16.51$, $p = .0001$.

Aptitude x Treatment Interactions

The following hypothesis was of major concern relative to Aptitude x Treatment interactions.

> There will be a differential relationship between criterion performance and aptitudes of subjects as measured by the vocabulary, curiosity, and invested mental effort measures.

Table 10
Analyses of Variance for Curiosity Levels

Source	df	SS	MS	F
Psychomotor Curiosity				
Pretest Written Science Curiosity	1	94726.56	94726.56	3.37
Residual	122	3428987.83	28106.46	
Total	123	3523714.39		
Posttest Written Science Curiosity				
Pretest Written Science Curiosity	1	241.54	241.54	11.63 *
Residual	122	2534.42	20.77	
Total	123	2775.96		
Posttest Written General Curiosity				
Pretest Written General Curiosity	1	127.95	127.95	16.51 *
Residual	121	937.71	7.75	
Total	122	1065.66		

* $p < .05$

Aptitude x Attention Cues x Test Cues

Since both attention cues and test cues were varied in the study, possible three-way interactions between student aptitudes and treatment conditions were investigated. A regression equation for a two-way analysis of covariance was utilized in order to detect any interactions. The possibility of an interaction for each treatment condition was derived by comparing the regression slopes. An Aptitude x Treatment interaction existed if the regression lines were significantly nonparallel. Analyses were employed using the factual items (constructed responses), the inferential items (forced choice and drawing items), the total posttest, and posttest science curiosity measure.

Three-way interactions were investigated using the 10 factual items as the dependent variable. No significant interactions were found for general curiosity, $F(1, 127) = .71$, $p = .40$; for science curiosity, $F(1, 122) = .11$, $p = .74$; for the amount of invested mental effort, $F(1, 127) = .19$, $p = .67$; or for psychomotor curiosity, $F(1, 127) = 1.15$, $p = .29$. A significant interaction was detected for verbal ability, $F(1, 127) = 4.38$, $p = .04$. The summary statistics for this Verbal Ability x Attention Cues x Test Cues interaction appear in Table 11.

Three-way interactions were also investigated using the 10 posttest inferential items as the dependent

Table 11
Summary of Statistics for Testing Interactions of Verbal Ability x Attention Cues x Test Cues

Source	df	SS	MS	F
Factual Items				
Verbal Ability x Attention x Test	1	19.65	19.65	4.38 *
Residual	127	570.55	4.49	
Total	128	590.20		
Inferential Items				
Verbal Ability x Attention x Test	1	4.03	4.03	1.25
Residual	127	408.77	3.22	
Total	128	412.80		
Total Posttest				
Verbal Ability x Attention x Test	1	41.50	41.50	4.09 *
Residual	127	1228.32	10.14	
Total	128	1329.82		
Posttest Science Curiosity				
Verbal Ability x Attention x Test	1	1.50	1.50	.06
Residual	127	2932.08	23.09	
Total	128	2933.58		

* $p < .05$

variable. No significant interactions were found for general curiosity, F(1, 122) = .89, p = .35; for science curiosity, F(1, 122) = .09, p = .76; for the amount of invested effort F(1, 127) = .20, p = .65; for psychomotor curiosity, F(1, 127) = .01, p = .91; or for verbal ability, F(1, 127) = 1.25, p = .26. The summary statistics for the Verbal Ability x Attention Cues x Test Cues interaction appear in Table 11.

Possible three-way interactions were investigated using the total posttest as the dependent variable. No significant interactions were found for general curiosity, F(1, 122) = 1.18, p = .28; for science curiosity F(1, 122) = .15, p = .70; for the amount of invested mental effort, F(1, 127) = .29, p = .59; or for psychomotor curiosity, F(1, 127) = .61, p = .44. A significant interaction was detected for verbal ability, F(1, 127) = 4.09, p = .04. The summary statistics for this verbal ability interaction are found in Table 11.

Finally, three-way interactions were investigated using posttest science curiosity as the dependent variable. No significant interactions were found for general curiosity, F(1, 122) = .26, p = .61; for science curiosity F(1, 122) = 1.51, p = .22; for the amount of invested mental effort, F(1, 127) = 1.23, p = .27; for psychomotor curiosity, F(1, 127) = 1.73, p = .19; or for verbal ability F(1, 127) = .06, p = .80. The summary statistics for the Verbal Ability x Attention Cues x

Test cues interaction appear with the other verbal ability interaction statistics in Table 11.

The existence of significant three-way interactions involving Verbal Ability x Attention Cues x Test Cues suggested further analyses. Two-way interactions for Verbal Ability x Attention Cues holding test cues constant and for Verbal Ability x Test Cues holding attention cues constant were examined.

Test Cues Constant

Analyses were performed to determine if interactions existed in the test cue treatments. No significant Verbal Ability x Attention Cues interactions were found for inferential items, $F(1, 66) = .34$, $p = .56$, or for the total posttest, $F(1, 66) = 2.45$, $p = .12$, although the interaction for factual items approached significance, $F(1, 66) = 3.46$, $p = .06$.

Attention Cues Constant

Additional analyses were performed to determine if interactions existed in the attention cue treatments. When attention cues were given, significant Verbal Ability x Test Cue interactions were found for factual items, $F(1, 59) = 7.74$, $p = .007$ and for the total posttest, $F(1, 59) = 9.07$, $p = .004$. A Verbal Ability x Test Cue interaction approached significance for the inferential items, $F(1, 59) = 3.79$, $p = .056$. When attention cues were not given, significant interactions were found for factual items, $F(1, 66) = 9.18$, $p = .004$ and for the total posttest, $F(1, 66) = 9.53$, $p = .003$. No significant interaction was found for inferential items, $F(1, 66) = 3.32$, $p = .07$. Summary statistics for these Verbal Ability x Test Cue interactions appear in Tables 12 and 13.

The above Verbal Ability x Test Cue interactions for factual items and for the total posttest are represented in Figures 1 and 2 respectively. Slopes and intercepts for the two dependent measures are summarized in Table 14.

For factual items, when attention cues were given, the interaction indicated a significant difference in the regression slopes of the test cue and no test cue treatments; the attention, no test condition (A-NT) with a negative slope favored students of low verbal ability and the attention, test cue condition (A-T) with a positive slope favored students of high verbal ability.

When no attention cues were given, the regression slopes of the test cue and no test cue condition were significantly different for factual items. The no test treatment again favored students of low verbal ability while the test cue treatment favored the high ability students.

For the total posttest, when attention cues were given, the same trend was detected. The no test cue condition favored the low ability students while the

Table 12
Statistics for Verbal Ability x Test Cue Interactions
(Attention Cues Given)

Source	df	SS	MS	F
		Factual Items		
Verbal Ability x Test Cue	1	29.57	29.57	7.74 *
Residual	59	225.51	3.82	
Total	60	255.08		
		Inferential Items		
Verbal Ability x Test Cue	1	10.56	10.56	3.79
Residual	59	164.65	2.79	
Total	60	175.21		
		Total Posttest		
Verbal Ability x Test Cue	1	75.49	75.49	9.07 *
Residual	59	490.87	8.32	
Total	60	566.36		

* $p < .05$

Table 13
Statistics for Verbal Ability x Test Cue Interactions
(No Attention Cues Given)

Source	df	SS	MS	F
		Factual Items		
Verbal Ability x Test Cue	1	40.53	40.53	9.18 *
Residual	66	291.47	4.42	
Total	67	332.00		
		Inferential Items		
Verbal Ability x Test Cue	1	11.09	11.09	3.32
Residual	66	220.38	3.34	
Total	67	237.47		
		Total Posttest		
Verbal Ability x Test Cue	1	94.04	94.04	9.53 *
Residual	66	651.43	9.87	
Total	67	745.47		

* $p < .05$

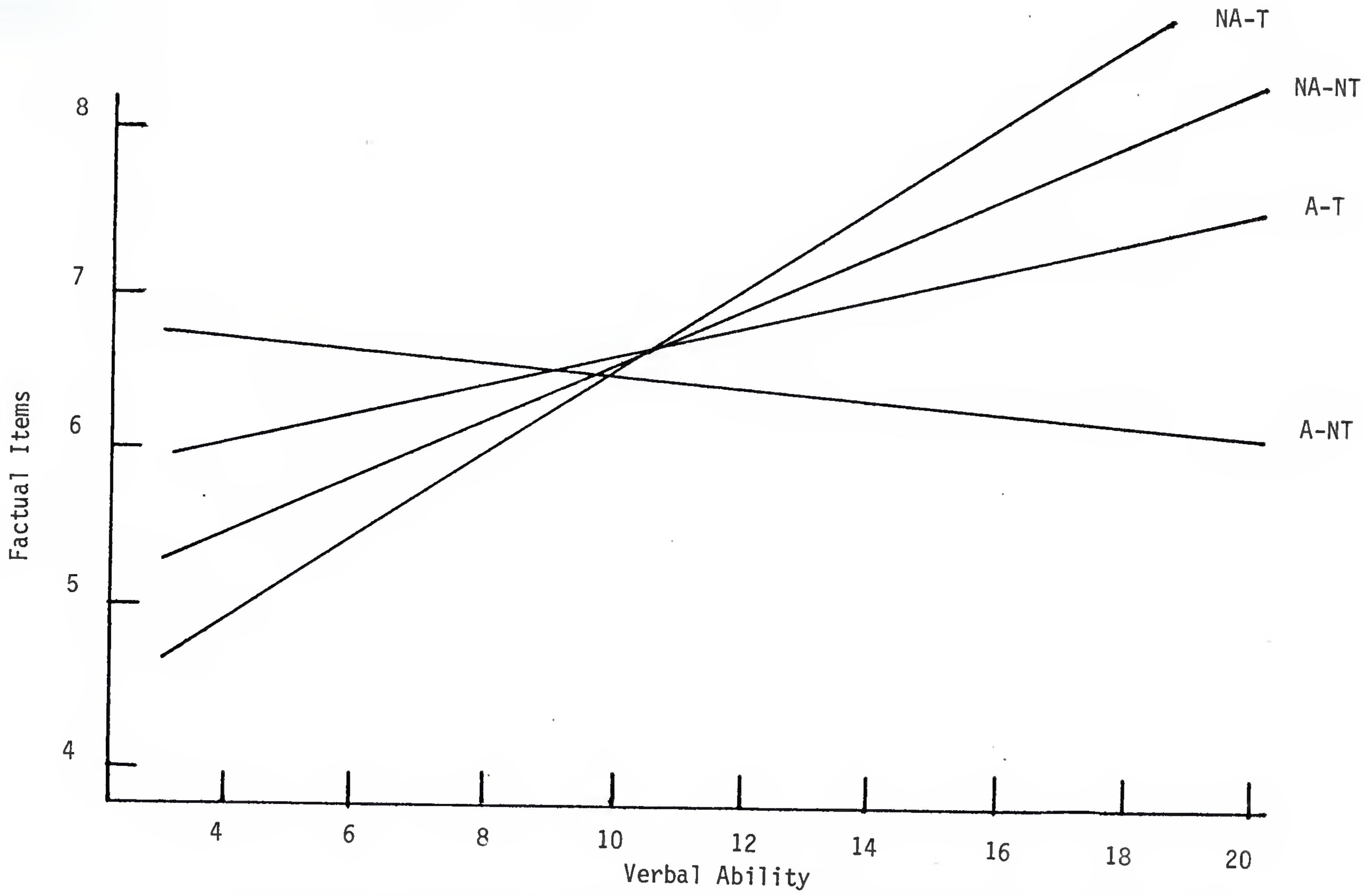


Figure 1. Interaction of Verbal Ability with Treatments for Factual Items

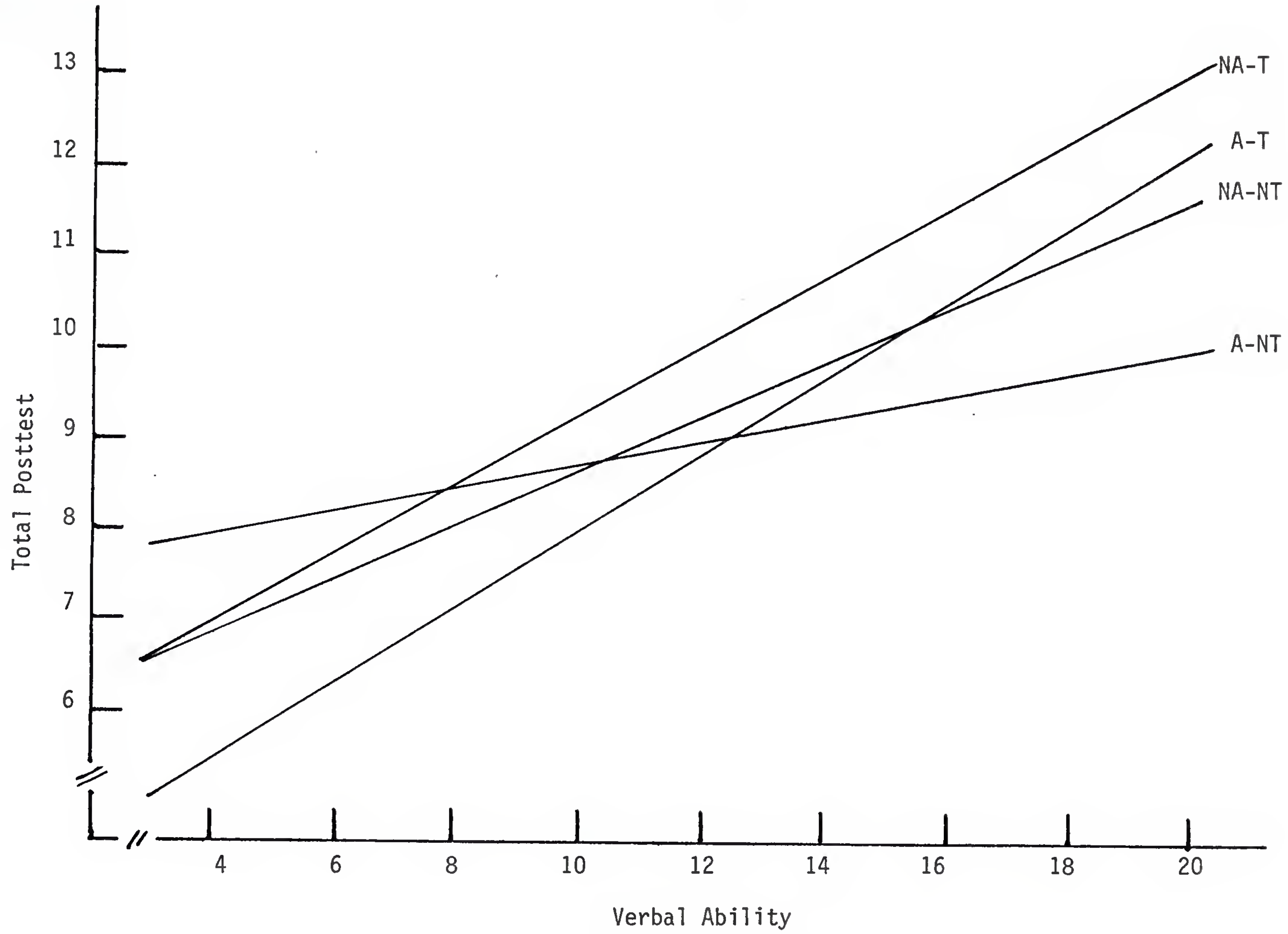


Figure 2. Interaction of Verbal Ability with Treatments for Total Posttest

Table 14
Intercepts and Slopes for Regression Lines
For Verbal Ability x Treatment Interactions

Treatment[a]	Intercept	Slope
	Factual Items	
A-T	5.9	.08
A-NT	7.0	-.03
NA-T	4.1	.24
NA-NT	5.0	.18
	Total Posttest	
A-T	4.15	.44
A-NT	7.73	.09
NA-T	5.72	.40
NA-NT	5.94	.32

[a] A-T = attention cues given, test cue given;
A-NT = attention cues given, no test cue given;
NA-T = no attention cues given, test cue given
NA-NT = neither attention cues nor test cue given.

test cue treatment favored the high ability students. When no attention cues were given, an ordinal interaction was found between the test cue condition and the no test cue condition.

Two-Way Interactions with Other Aptitudes

Since no three-way interactions of Aptitude x Test Cue x Attention Cues were detected for science curiosity, psychomotor curiosity, and the amount of mental effort, analyses were performed investigating possible two-way interactions. The following 24 combinations of independent and dependent variables were used to investigate Aptitude x Treatment interactions:

1. Science Curiosity x Attention Cues for factual items,
2. Science Curiosity x Attention Cues for inferential items,
3. Science Curiosity x Attention Cues for total posttest,
4. Science Curiosity x Attention Cues for posttest written curiosity,
5. Psychomotor Curiosity x Attention Cues for factual items,
6. Psychomotor Curiosity x Attention Cues for inferential items,
7. Psychomotor Curiosity x Attention Cues for total posttest,

8. Psychomotor Curiosity x Attention Cues for posttest written curiosity,
9. Amount of Invested Mental Effort x Attention Cues for factual items,
10. Amount of Invested Mental Effort x Attention Cues for inferential items,
11. Amount of Invested Mental Effort x Attention Cues for total posttest,
12. Amount of Invested Mental Effort x Attention Cues for posttest written curiosity,
13. Science Curiosity x Test Cue for factual items,
14. Science Curiosity x Test Cue for inferential items,
15. Science Curiosity x Test Cue for total posttest,
16. Science Curiosity x Test Cue for posttest written curiosity,
17. Psychomotor Curiosity x Test Cue for factual items,
18. Psychomotor Curiosity x Test Cue for inferential items,
19. Psychomotor Curiosity x Test Cue for total posttest,
20. Psychomotor Curiosity x Test Cue for posttest written curiosity,

21. Amount of Invested Mental Effort x Test Cue for factual items,
22. Amount of Invested Mental Effort x Test Cue for inferential items,
23. Amount of Invested Mental Effort x Test Cue for total posttest,
24. Amount of Invested Mental Effort x Test Cue for posttest written curiosity.

Of the above 24 interactions studied, 3 significant interactions were detected. When posttest written science curiosity was the dependent variable, significant interactions were found for Pretest Science Curiosity x Attention Cues $\underline{F}(1, 122) = 4.35$, $\underline{p} = .04$; for the Amount of Invested Mental Effort x Test Cue, $\underline{F}(1, 127) = 4.21$, $\underline{p} = .04$; and for Psychomotor Curiosity x Test Cue, $\underline{F}(1, 127) = 4.51$, $\underline{p} = .04$. $\underline{F}$ values for the nonsignificant interactions appear in Tables 15 and 16. The statistics for the significant interactions are summarized in Table 17. Figures 3, 4, and 5 represent the regression lines for the significant interactions; the slopes and intercepts are found in Table 18.

Follow-up Bonferroni $\underline{t}$ tests on the Pretest Science Curiosity x Attention Cues interaction detected the difference to be between the attention cues, no test cue treatment (A-NT) versus the no attention cues, no test cue treatment (NA-NT). The attention cue condition

Table 15
Nonsignificant F Values for Aptitude x Treatment Interactions for Factual Items and Inferential Items

Interaction	df	F
Factual Items		
Science Curiosity x Attention	1, 122	.96
Science Curiosity x Test Cue	1, 122	.02
Mental Effort x Attention	1, 127	1.90
Mental Effort x Test Cue	1, 127	.01
Psychomotor Curiosity x Attention	1, 127	3.01
Psychomotor Curiosity x Test Cue	1, 127	1.49
Inferential Items		
Science Curiosity x Attention	1, 122	1.10
Science Curiosity x Test Cue	1, 122	.09
Mental Effort x Attention	1, 127	3.43
Mental Effort x Test Cue	1, 127	.00
Psychomotor Curiosity x Attention	1, 127	.79
Psychomotor Curiosity x Test Cue	1, 127	.20

Table 16
Nonsignificant F Values for Aptitude x Treatment Interactions For Total Posttest and Posttest Science Curiosity

Interaction	df	F
Total Posttest		
Science Curiosity x Attention	1, 122	1.53
Science Curiosity x Test Cue	1, 122	.00
Mental Effort x Attention	1, 127	3.58
Mental Effort x Test Cue	1, 127	.00
Psychomotor Curiosity x Attention	1, 127	2.74
Psychomotor Curiosity x Test Cue	1, 127	1.13
Posttest Written Science Curiosity		
Science Curiosity x Test Cue	1, 122	3.56
Mental Effort x Attention	1, 127	3.80
Psychomotor Curiosity x Attention	1, 127	3.12

Table 17
Summary Statistics for Significant Two Way Interactions

Source	df	SS	MS	F
Posttest Written Science Curiosity				
Science Curiosity x Attention Cues	1	95.64	95.64	4.35 *
Residual	122	2680.32	21.97	
Total	123	2775.96		
Posttest Written Science Curiosity				
Amount of Invested Mental Effort x Test Cue	1	94.10	94.10	4.21 *
Residual	127	2839.49	22.36	
Total	128	2933.59		
Posttest Written Science Curiosity				
Psychomotor Curiosity x Test Cue	1	100.66	100.66	4.51 *
Residual	127	2832.92	22.31	
Total	128	2933.58		

* $p < .05$

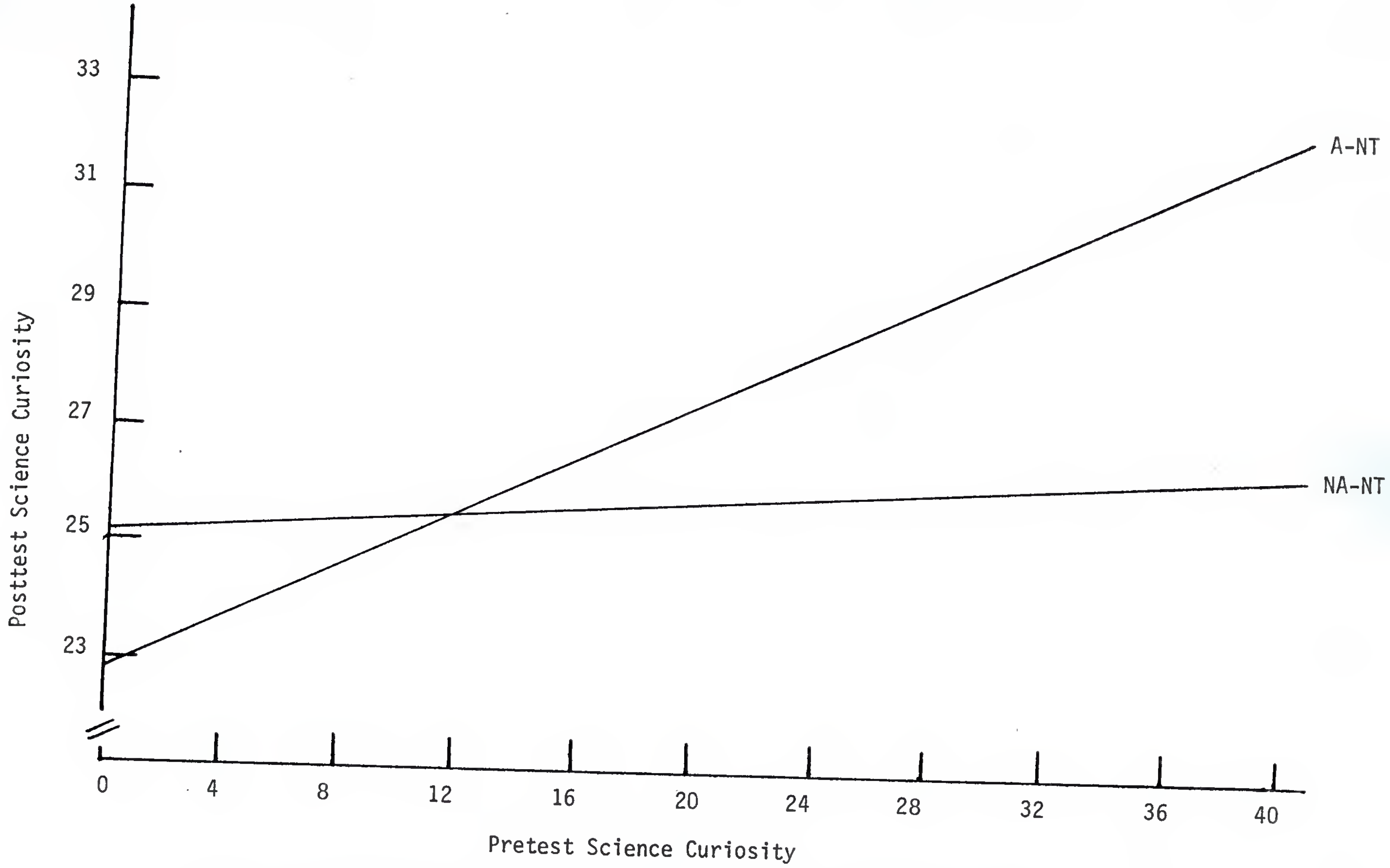


Figure 3. Interaction of Pretest Science Curiosity x Attention Cues for Posttest Science Curiosity

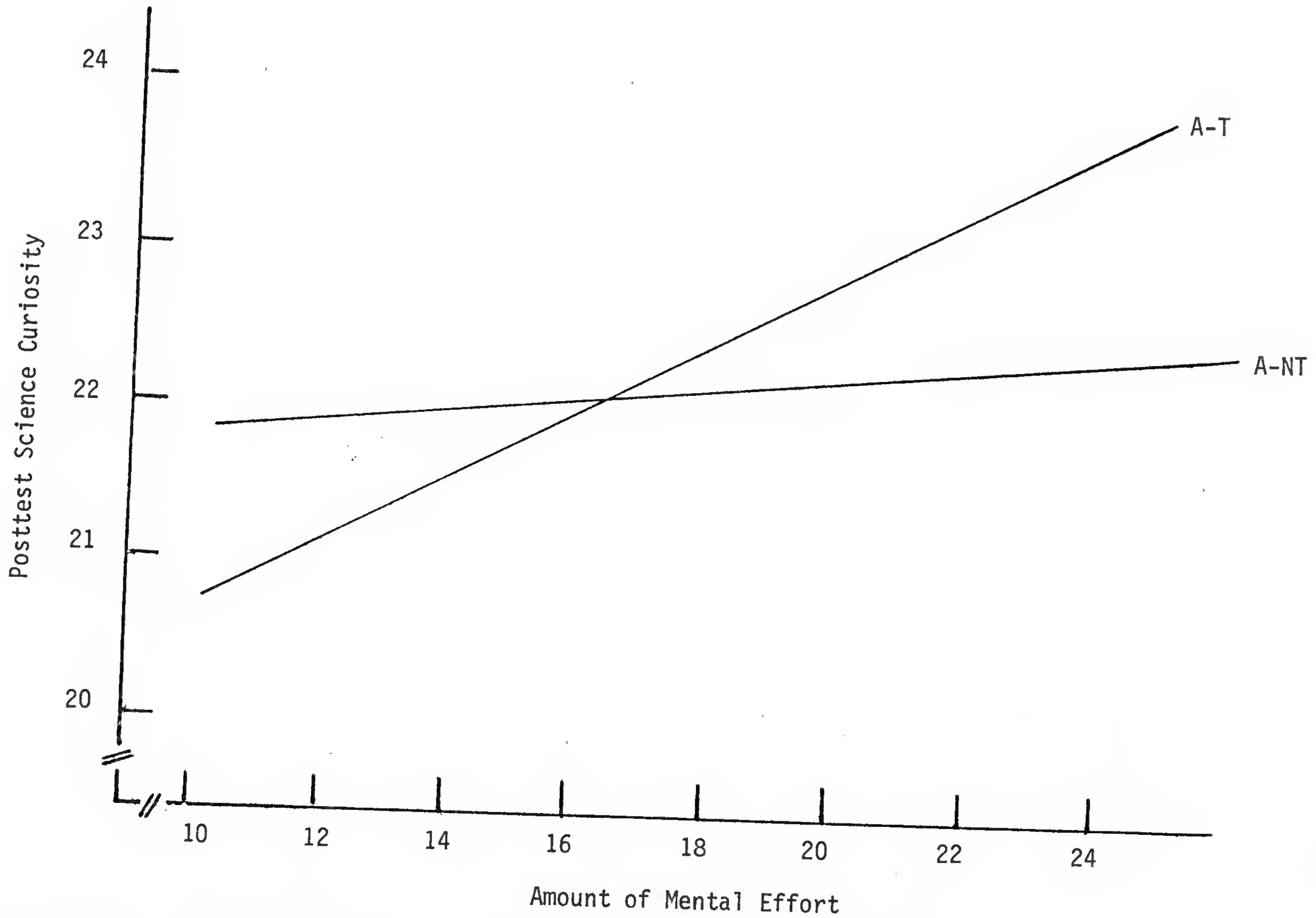


Figure 4. Interaction of Amount of Mental Effort x Test Cue for Posttest Science Curiosity

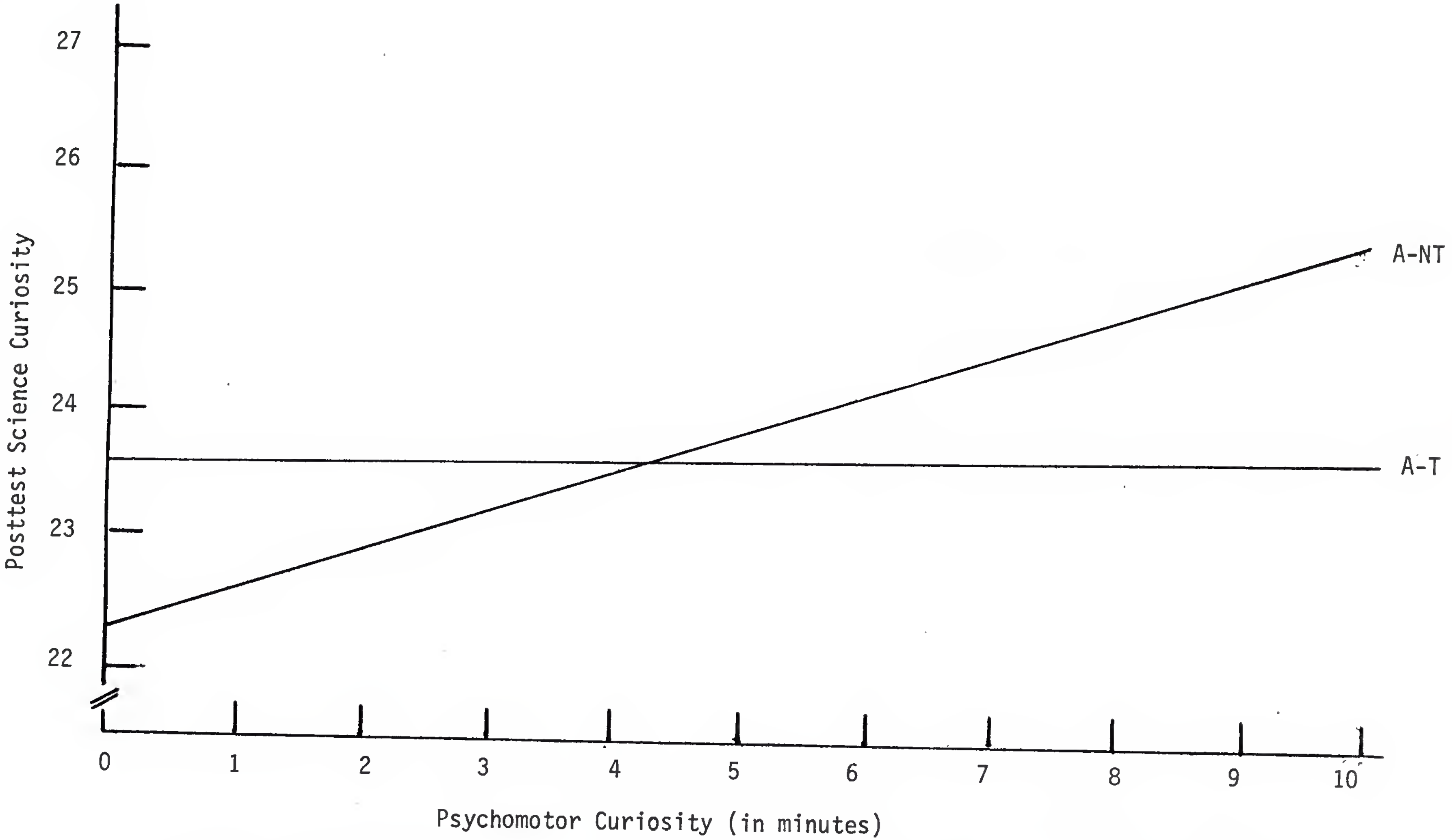


Figure 5. Interaction of Psychomotor Curiosity x Test Cue for Posttest Science Curiosity

Table 18
Intercepts and Slopes for Regression Lines
For Posttest Written Science Curiosity
As the Dependent Variable

Treatment[a]	Intercept	Slope
Pretest Science Curiosity x Attention Cues Interaction		
A-NT	23.0	.23
NA-NT	25.1	.01
Amount of Mental Effort x Test Cue Interaction		
A-T	19.8	.10
A-NT	21.7	.02
Psychomotor Curiosity x Test Cue Interaction		
A-T	23.6	.01
A-NT	22.3	.24

[a] A-T = attention cues given, test cue given;
A-NT = attention cues given, no test cue given;
NA-NT = neither attention cues nor test cue given.

resulted in higher posttest science curiosity scores for those subjects with higher pretest science curiosity scores while the no attention cue condition favored those subjects who had lower pretest science curiosity scores.

The Amount of Mental Effort x Test Cue interaction indicated for the attention, no test cue treatment (A-NT) the regression line was flatter; thus students who invested a low amount of mental effort benefited more from a treatment with those conditions. For those students who invested a high amount of mental effort, the attention cues, test cue treatment (A-T) produced higher posttest science curiosity scores.

Follow-up Bonferroni _t_ tests on the Psychomotor Curiosity x Test Cue interaction indicated that the nature of the difference was between the attention cues, test cue treatment (A-T) versus the attention cues, no test cue treatment (A-NT). Subjects who spent more time exploring the shells in the exhibit had higher posttest science curiosity scores in the A-NT treatment; thus subjects who explored less had higher posttest science curiosity scores in the attention, test cue treatment.

CHAPTER V
DISCUSSION AND IMPLICATIONS

This study examined the effects of the presence or absence of attention cues and the presence or absence of test cues upon learning achievement in a museum setting. Posttest curiosity was examined in relation to these cues and pretest curiosity. Also of interest was what treatment modifications appeared best for particular types of students. Some principles upon which this study was based included the following:

1. Since attention is necessary for learning to take place, many students require cues and focusing devices to hold their attention.
2. Structure and organization of the material to be learned reduces the internal processing burden placed upon the learner.
3. Any variable such as knowledge of the criterion task may influence the learner's perception of the task, thereby influencing the amount of mental effort invested by the learner.
4. Curiosity increases interest and manipulation.
5. The effectiveness of the treatments will vary due to the differences in learner aptitudes.

Instructional Treatment Main Effects

Cues

The first two hypotheses tested were

1. Subjects receiving treatment cards with attention focusing questions about the museum exhibit will perform significantly better on a written criterion measure than subjects receiving treatment cards with no attention cues.
2. Subjects receiving treatment cards with cues that refer to a forthcoming achievement test about the exhibit will perform significantly better on the criterion measure than subjects receiving treatment cards with no reference to a test.

In order to investigate main effects for attention cues and test cues, a regression equation was used containing both attention cues and test cues as components of the regression model. Dependent measures included the constructed factual items, the inferential items, and the total posttest. A significant $\underline{F}$ statistic would have indicated differences between treatment conditions; however, no significant main effects were detected for either attention cues or for test cues with any of the dependent measures.

These students may have considered the experience "fun" rather than educational--a welcome escape from the regular classroom agenda; therefore, they may not have taken advantage of the cues for the purpose of learning. Since pre-orientation to the museum exhibit was not part of the experimental design, subjects were not alerted to the educational objectives of the exhibit. Researchers (Gennaro, 1981; P. M. Smith, 1981; Wright, 1980) demonstrated that subjects who were not oriented to a museum or field trip learned less than those subjects who had been pre-oriented by materials or by other means. This may have contributed to these subjects' mere perusal rather than specific study of the shell exhibit.

In addition to the lack of focus toward an eductional outcome, the existence of the "novelty interference" phenomenon may have been at work here. Exposure to an exhibit for these students may have had much the same effect as the "novel" field trip--primarily reducing their focus of attention and reducing the coding of specific salient features of the exhibit (Falk et al., 1978; Falk & Balling, 1980; Gennaro, 1981; Sneider et al., 1979). These students also may have not known how to use cues that were provided since this frequently is not taught in the classroom and was not part of this particular study. Without utilizing the cues given, the effect on these subjects could have been a reduction in attention which resulted in their inability to code information which, in turn, interfered with their memory storage and retrieval capabilities as outlined by learning theorists (Bransford, 1979; Gagné, 1977). Another explanation is that attention cues alone or test cues alone are not adequate in and of themselves to influence effective coding and memory storage. Similarly, the lack of a memory structure as Shettel et al. (1968) referred to in that study, may have acted to negate the effects of the attention cues even if some short term storage did occur. A follow up discussion on these possibilities is presented in the section on Aptitude x Treatment interactions. The data, therefore, did not support either the first or second hypothesis.

Mental Effort and Inferences

The third hypothesis tested was

3. Subjects receiving treatment cards with test cues will be influenced to invest more mental effort and will perform significantly better on the inference portion of the criterion measure than subjects not receiving these cues.

Analyses of variance were performed using the amount of invested mental effort and the inferential portion of the criterion measure as the dependent variables. A significant *F* statistic indicated differences between treatment conditions. Bonferroni _t_ tests were used to detect the nature of any differences.

When the inference portion of the criterion test was the dependent measure, a significant mental effort effect was detected. As anticipated, subjects who invested more mental effort were able to make more and better inferences than those who invested less mental effort. This finding is in accordance with that of Salomon (1984). He reported that those subjects who perceived learning from print more difficult than learning from television applied more mental elaborations and used more cognitive strategies during the task than those who perceived the task as easy. In addition to a high perceived demand characteristic (PDC), these learners were also likely to have a high level of perceived self-efficacy (PSE) which Salomon found to be related to the amount of invested mental effort. Thus, attention was more focused, for longer periods of time, facilitating both coding and memory storage. Hence, these students made more and better inferences from the information they were able to store.

When the inference portion of the criterion measure was the dependent variable, a significant test cue effect was detected. Follow-up tests indicated that the treatment that contained test cues only was superior to the treatment that consisted of both test cues and attention cues. This finding is supported by Salomon's (1983) contention that students are influenced to invest more mental effort due to their own perception of the task's worth, how much attention they should give to it, how they should learn it, and how deeply they should learn it.

The treatment with both test cues and attention cues appeared to contain attention cues that students did not need, that they did not utilize, or that they discarded. Students may have discarded the cues because such cues interfered with their own cognitive strategies and abilities to attend to the stimuli presented in the shell exhibit, code the information, and store it in memory (Dansereau, 1982b; Holliday, 1981; Reidbord, 1979). If students did utilize the attention cues, they could have perceived them as "forward shaping" cues (Anderson, 1970; Rothkopf, 1970; J. T. Wilson & Koran, 1976). This type of cue usually preconditions students to find only those answers germane to the attention cues given while hindering their ability to acquire and code for incidental learning (inferences) not specified by the attention cues (Frase, 1968; J. T. Wilson, 1973).

Those in the treatment with test cues only were able to make more and better inferences, perhaps because there were no attention cues to interfere with their own cognitive strategies and their perception of the importance of the task. These students may have been influenced by the test cue alone to perceive the task as important to learn thereby giving the task the necessary attention without written attention cues. Then by applying their individual appropriate mental elaborations to the task, they were able to process the information at a deeper more meaningful level than those in the attention cue group. This deep processing (Bransford, 1979) enabled them to make superior inferences. Thus, the data supported the third hypothesis.

Curiosity

The fourth hypothesis tested was

4. Subjects who demonstrate high levels of written curiosity before approaching the exhibit will perform significantly better on both the psychomotor and written curiosity measures after their interaction with the exhibit than subjects who have low levels of written curiosity.

Although there was no significant effect for pretest written science curiosity when psychomotor curiosity was the dependent measure, it approached significance. These 2 variables were significantly correlated, but a written form of curiosity did not predict psychomotor curiosity. In light of the many constructs of curiosity found in the literature (Hazen, 1982; Kreitler et al., 1975; R. W. Peterson & Lowery, 1972), it is not surprising that some students preferred to express curiosity in a written form, some as exploratory or psychomotor behaviors, and some as verbal behaviors which included students' unsolicited questions.

When posttest written science curiosity was the dependent measure, pretest written curiosity was found to be significant. Similarly, when posttest written general curiosity was the dependent measure, there was a significant general written curiosity effect. The respective pretest and posttest curiosity measures were also significantly correlated. When each written pretest had a corresponding written posttest, the same type of curiosity was measured within each set of curiosity levels. Each pretest curiosity measure itself could have functioned as a cueing or attention focusing device, particularly since it was given only a week prior to the posttest. Thus, the data partially supported hypothesis 4 when written measures were given both as a pretest prior to, and as a posttest after, the subjects' interaction with a hands-on museum exhibit.

The descriptive statistics indicated that the opportunity to manipulate the shells in the exhibit, no matter what the treatment, produced an increased mean written posttest curiosity score. This outcome could have been due to the novelty of a manipulative exhibit which may have encouraged students to express behaviors they did not previously possess. This correlates with previous research on the attraction of participatory exhibits (J. J. Koran et al., 1984; Oppenheimer, 1972).

Aptitude x Treatment Interactions

The fifth hypothesis tested was

5. There will be a differential relationship between criterion performance and aptitudes of subjects as measured by the vocabulary, curiosity, and invested mental effort measures.

This hypothesis was tested by comparing the regression slopes for each treatment condition. An Aptitude x Treatment interaction existed if the regression lines were significantly nonparallel.

Three-Way Interactions

Significant three-way interactions were detected for the aptitude of Verbal Ability x Attention Cues x Test Cues. Additional analyses revealed the nature of the interaction. For the attention cue treatments, the Verbal Ability x Test Cue interaction was significant for factual items and for the total posttest. For both dependent variables, the attention cues, no test cue treatment (A-NT) was better for subjects scoring lower in verbal ability while the no attention cues, test cue (NA-T) treatment was better for those scoring higher in verbal ability.

Since subjects low in verbal ability need attention devices, cues, and explicit rules to follow during a learning situation in order to reduce the demand on their own cognitive proceses (A. L. Brown et al., 1981; Dansereau, 1982a; Ebmeier, 1978), the attention cue treatment provided this instructional support. This treatment enabled low ability learners to systematize incoming stimuli by having their attention alerted to what was important as it provided them with a framework for the information they were to learn from the exhibit.

Conversely, high ability students have been found to perform best in a task-oriented environment which leaves much of the cognitive processing and organization to the learner (Ebmeier, 1978; Reidbord, 1979). The no attention cues, test cue treatment (NA-T) fits into this descriptive category. The test cue defined the task for high ability students and, without attention cues, these subjects could develop their own strategies for learning rather than being constrained in their thinking by specific attention cues. Thus, high ability students did better in this type of treatment.

Vocabulary was the only aptitude with which there were significant three-way interactions. There were none for Curiosity or for the Amount of Invested Mental Effort x Attention Cues x Test Cues with the dependent variables of factual items, inferential items, or total posttest. This is consistent with previous Aptitude x Treatment research (Cronbach & Snow, 1977) that has demonstrated that general ability, of which verbal is an index, has repeatedly been the most common aptitude found to enter into interactions.

Two-Way Interactions

Significant two-way interactions were detected when posttest written science curiosity was the dependent measure for the following: (1) Pretest Written Science Curiosity x Attention Cues, (2) the Amount of Invested Mental Effort x Test Cue, and (3) Psychomotor Curiosity x Test Cue.

Follow-up analyses of the Pretest Written Science Curiosity x Attention Cues detected the nature of the difference. The no attention cues, no test cue treatment (NA-NT) benefited those students who had lower pretest science curiosity scores; the attention cues, no test cue treatment (A-NT) was better for those subjects with higher pretest science curiosity scores. One interpretation is that subjects low in pretest written science curiosity were stimulated by the novel, hands-on stimulus of the shell exhibit; they were not distracted with attention cues, but could fully explore the various sizes, shapes, textures, and complexities of the shells. Perhaps those who were high in pretest written science curiosity were so curious that the attention cues served to channel their curiosity to the specifics delineated by the attention cues. The no test cue condition was better for both high and low curiosity subjects which allowed them to pursue their curious ideas without the threat of being tested on content.

The Amount of Mental Effort x Test Cue interaction indicated that students who invested a low amount of mental effort benefited from the attention, no test cue treatment (A-NT) when curiosity was the criterion measure. For those students who invested a high amount of mental effort, the attention cues, test cue treatment (A-T) produced higher posttest science curiosity scores. Those subjects who reported investing a low amount of mental effort did not think that the task was important or worth learning; therefore, the attention cues served to focus their attention to the differences in the shells of the exhibit and perhaps spawned their curiosity. The no test condition allowed curiosity of these subjects to be nurtured without the imposition of a test.

Those subjects who reported they invested a high amount of invested mental effort thought the task was important to learn and were very task-oriented. The attention cues provided them with an outline of what features of the shells they should have been concerned about learning. The knowledge of a forthcoming test could have increased their mental effort thereby contributing to the higher mental effort scores which were measured immediately after they viewed the exhibit. The higher posttest written science curiosity scores by these subjects could have resulted by chance or because these students also had higher pretest written science curiosity levels.

Follow-up tests on the Psychomotor Curiosity x Test Cue interaction indicated that subjects who explored less had higher posttest written science curiosity scores in the attention, test cue treatment (A-T). One possible explanation is that these students may have expressed their curiosity as written rather than as psychomotor. The attention cues could have served to heighten their passive cognitive exploration versus active psychomotor exploration (Kreitler et al., 1975). These subjects may have been stimulated to perceive the novelty and irregularity of the shells in the exhibit as prompted by the attention cues. Along with the deep cognitive processing of students, these cues may have enabled them to effectively code the information into memory. J. J. Koran and Longino (1982) proposed that when information is retrieved from memory, the retrieval evokes a response that perpetuates curiosity. Thus, these subjects could have responded to their retrieval of information by exhibiting higher written posttest curiosity even though the observed psychomotor curiosity was low. These subjects may have also responded to the test cue with increased cognitive exploration. Knowledge of an impending test has been found to enhance performance (Wong et al., 1982) and perhaps the enhancement for these students was in the form of increased written curiosity.

Subjects who spent more time exploring the shells in the exhibit had higher posttest written science curiosity scores in the attention cues, no test cue treatment (A-NT). These students expressed their curiosity as psychomotor during the time they were in the vicinity of the shell exhibit. The attention cues may have redirected this curiosity and may have helped these students cognitively perceive, process, and internalize their psychomotor curiosity. As they coded what they learned from their exploratory behavior into memory, it reinforced responsiveness. Since their only means to convey this response directly after the hands-on museum experience was written, their process of information retrieval may have evoked their cognitive curiosity which they expressed as posttest written curiosity.

The no test cue condition may have allowed these subjects to pursue their curiosity without the threat of being tested on content. Since these subjects had a higher mean in verbal ability, it allowed them to process a great amount of sensory data (Allen, 1975). Thus, the exploratory behavior that was observed by the experimenters could have been accompanied by cognitive exploration about which the experimenters were not aware. Curiosity, as explained by Kreitler et al. (1975), is not a unitary construct; therefore, curiosity could be expressed by students in one or in several forms. Data showed that these students expressed curiosity both as psychomotor and as written on the posttest; this partially supported the fifth hypothesis.

In summary, three-way interactions were found with vocabulary as the aptitude. In general, lower ability students benefited from attention cues which provided them with needed instructional support as suggested by Tobias (1982). Higher ability students performed better without attention cues as these subjects had their own learning strategies upon which they could draw. The no test cue condition was better for lower ability students while the test cue condition benefited the higher ability, more task-oriented students (Cronbach & Snow, 1977; Ebmeier, 1978).

Two-way interactions were detected when posttest written science curiosity was the dependent variable and when pretest science curiosity, the amount of invested mental effort, and psychomotor curiosity were each an independent variable. Factors which may have led to low power in detecting other interactions were the numbers of subjects in each treatment as well as the length of the treatment. Cronbach and Snow (1977) suggested that minimum of 100 subjects per treatment and treatments that lasted several weeks be incorporated into studies attempting to find Aptitude x Treatment interactions. In this initial study investigating the effect of cues, verbal ability, and curiosity upon learning from a museum exhibit, these suggestions were not deemed practical. In fact, if followed, these conditions may have led to serious questions of internal validity.

Some of the sources of invalidity that were controlled for in this short study were history, maturation, and mortality. History was controlled as each group of students was sequestered during the week of the study during school hours. Students did not discuss what they had experienced with their peers and there was no possible access to a museum for these subjects for the duration of the experiment. These factors were monitored by the teachers and by the experimenters.

Maturation did not present a threat to validity in this study due to its short duration. If a study were to be carried out over an extended period such as a school year, maturation would pose a problem.

Mortality can easily become a problem in areas where people are quite transient and children leave school. It would be quite difficult to conduct a long-range study in a public school in rural Florida. In this study, mortality was not a threat as the study was conducted within a two week period.

The low reliability coefficients calculated for the AIME Scale (0.38), the Factual Posttest (0.60), and the Inferential Postest (0.57) would account for reduced chances of more interactions being detected. Although the AIME Scale in Salomon's (1984) study was reported to have a Cronbach Alpha of 0.81, only a general description was given concerning the types of questions used. The scale was applied to the learning of a story, a more detailed and more explicit formal experience, and not to a museum study. Future museum research might focus on developing more reliable measures.

Another factor which may have presented some difficulty in this study was that an adult was present during the time the subjects were perusing and/or learning from the exhibit. R. W. Peterson (1975) found that this depressed the curiosity expression of subjects.

Conclusion

Although many educators, psychologists, and textbook writers have professed the theory that attention cues and tests cues are helpful for all students to reach certain educational goals, no research studies were located that investigated different types of students' achievement or their resultant curiosity after a hands-on museum exhibit encounter utilizing treatments with and without such cues. This study found that giving students attention cues and/or test cues did not ensure that learning would take place. The fact that no main effects were found was not discouraging; rather, an Aptitude x Treatment effect was found with verbal ability as the aptitude. Lower ability students were found to do better with attention cues while those of higher verbal ability did better without attention cues.

Lower ability students also benefited from a treatment that contained no test cues while higher ability students performed best in a task-oriented test cue condition. Perhaps low ability students, who usually have low self-esteem, and perceive themselves as having low self-efficacy, are threatened by and have increased anxiety when they know they are to be tested. Although anxiety was not an aptitude measured in this study, it has been found that low ability, high anxiety students achieved more when there was high structure and when no demands were made on them (P. Peterson, 1977; Seiber, 1977). Perhaps this accounts for the advantage the attention cue, no test cue condition had for the low ability students in this study. Additional research is needed using different museum exhibits, different ability students with various aptitudes, and research that takes place for varying periods of time.

Salomon's (1983, 1984) research concerning the amount of invested mental effort and its effect upon inferential learning was extended in this study. Students who chose to invest more mental effort while studying the museum exhibit were able to make significantly more and better inferences. A test cue only treatment seemed to influence students to perceive the task as important to learn; therefore, they were able to make superior inferences.

The paradigm that curiosity is a multi-dimensional construct was substantiated in this study. A written form of science curiosity did not predict the psychomotor or exploratory form of curiosity; however, a pretest written form of curiosity did significantly predict the posttest written form of curiosity after the hands-on type of museum exhibit experience. Although the opportunity to manipulate the shells in the exhibit produced an increased mean written curiosity score, curiosity, as measured in this study, was not found to have a significant main effect upon learning from a museum exhibit. Perhaps an exhibit that allows the learner to solve a problem with greater interaction would be more appropriate in future research studies to discern the effects of students' curiosity levels upon learning. Further research is needed that encompasses students' science curiosity in written, psychomotor, and verbal forms while employing a high power design in order to detect any possible Aptitude x Treatment interaction effects.

APPENDIX A
EXAMPLES OF THE WRITTEN TREATMENT CARDS

Card # 1: Attention Cues and Test Cues Given (A-T):

PLEASE READ THIS CARD CAREFULLY

DIRECTIONS:

1) You may touch and look at these shells.
2) You may be at the exhibit for up to 10 minutes.
3) Learn as much as you can about the shells. You will be given a TEST after you are finished to see how much you have learned.
4) Please return each shell to its place when finished.

SOME CLUES:

1) A univalve is a shell that is all one part.
2) A bivalve is a shell that has two parts or two halves that look alike.
3) Bivalves were connected together by muscles. They acted like a hinge on a door.
4) Most muscles come loose after the animal dies.

SOME MORE CLUES:

1) How are the shells the same or different in:
   a) color?
   b) shape?
   c. size?
   d. roughness or smoothness?
2) Is there anything unusual about any of the shells?
3) What different kinds of animals lived inside the different kinds of shells?

Card # 2: No Attention Cues Given, Test Cues Given (NA-T):

PLEASE READ THIS CARD CAREFULLY

DIRECTIONS:

1) You may touch and look at these shells.
2) You may be at the exhibit for up to 10 minutes.
3) Learn as much as you can about the shells. You will be given a TEST after you are finished to see how much you have learned.
4) Please return each shell to its place when finished.

SOME CLUES:

1) A univalve is a shell that is all one part.
2) A bivalve is a shell that has two parts or two halves that look alike.
3) Bivalves used to be connected together by muscles. They acted like a hinge on a door.
4) Most muscles come loose after the animal dies.

Card # 3: Attention Cues Given, No Test Cues Given (A-NT):

PLEASE READ THIS CARD CAREFULLY

DIRECTIONS:
1) You may touch and look at these shells.
2) You may be at the exhibit for up to 10 minutes.
3) Please return each shell to its place when finished.

SOME INFORMATION:
1) A univalve is a shell that is all one part.
2) A bivalve is a shell that has two parts or two halves that look alike.
3) Bivalves were connected together by muscles. They acted like a hinge on a door.
4) Most muscle hinges come loose after the animal dies.

SOME THINGS TO THINK ABOUT:
1) How are the shells the same or different in:
    - a) color?
    - b) shape?
    - c) size?
    - d) roughness or smoothness
2) Is there anything unusual about any of the shells?
3) What different kinds of animals lived inside the different kinds of shells?

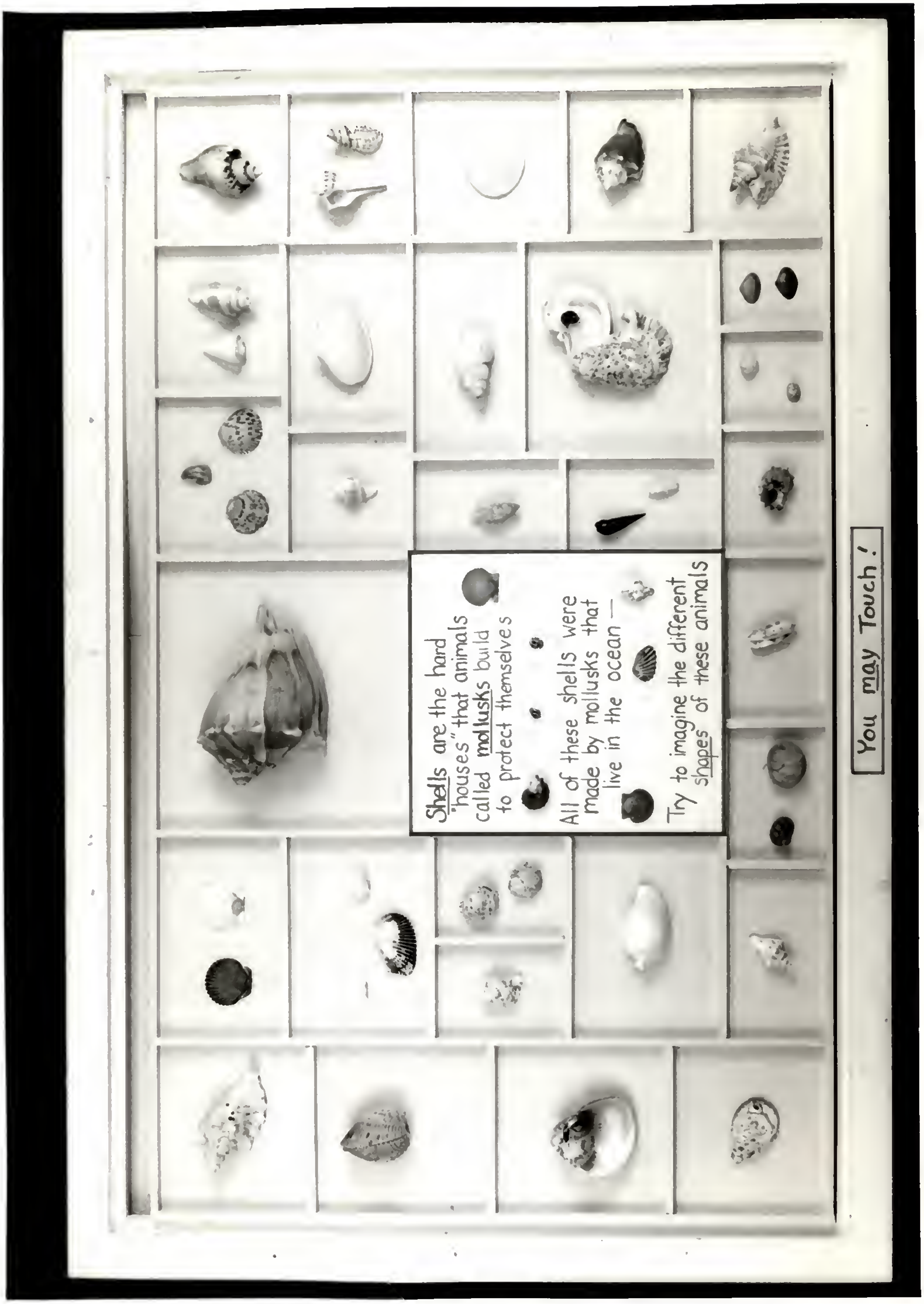
Card # 4: No Attention Cues nor Test Cues Given (NA-NT):

PLEASE READ THIS CARD CAREFULLY

DIRECTIONS:
1) You may touch and look at these shells.
2) You may be at the exhibit for up to 10 minutes.
3) Please return each shell to its place when finished.

SOME INFORMATION:
1) A univalve is a shell that is all one part.
2) A bivalve is a shell that has two parts or two halves that look alike.
3) Bivalves were connected together by muscles. They acted like a hinge on a door.
4) Most muscle hinges come loose after the animal dies.

APPENDIX B
PHOTOGRAPH OF THE SHELL EXHIBIT



APPENDIX C

QUESTIONS USED FOR THE GENERAL SCIENCE CURIOSITY SCALE
(Modified and Adapted from Penney and McCann, 1964)

DIRECTIONS: There are no right or wrong answers. Read each of the statements below and Circle T for True, or F for False, showing how you feel.

1. I like to wear the same kinds of outfits usually. T F
*2. I like everyone I meet. T F
3. I like to visit zoos. T F
4. The TV news is boring. T F
5. It's fun to go to the mall to look around. T F
6. I like to try different kinds of foods. T F
7. It would be fun to visit someone in another town. T F
8. I would rather stay home than go to the mall. T F
*9. I don't even tell small lies. T F
10. I like to visit museums. T F
11. I like to eat in different restaurants. T F
12. It's fun to see the inside of old buildings. T F
13. I like to read about people who live in other countries. T F
*14. I always say the right things to everyone. T F
15. It's fun to watch men working outdoors. T F
16. I usually drink the same kind of soda. T F
17. I only have one hobby. T F
18. I like to go on vacation or go to camp. T F
19. I like to watch the rain. T F
*20. I never get mad at anyone. T F

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* Lie items.

APPENDIX D

EXAMPLES FROM THE SCIENCE CURIOSITY SCALE

(Adapted from Harty and Beall, 1984)

DIRECTIONS: There are no right or wrong answers. Place the number which shows how you feel in the blank that follows each statement.

4 = Very much so
3 = Moderately so
2 = Somewhat
1 = Not at all

1. I like to watch science fiction movies. ______
2. It is boring to read about plants and animals. ______
3. I want to know why it is windy sometimes. ______
4. I would like to see scientists in their laboratories. ______
5. I like to go to the planetarium and see the stars. ______
6. I don't like to do any science experiments. ______
7. I'd like to know more about space travel and the space shuttle. ______
8. I like to take things apart and put them together again. ______
9. I'd like to find out how animals know when to hibernate. ______
10. I like to watch how clouds make pictures in the sky. ______

APPENDIX E

AIME SCALE (AMOUNT OF INVESTED MENTAL EFFORT)
(Adapted from Suggestions by Salomon, 1983)

DIRECTIONS: Please be HONEST when giving your answers. Circle the answer that best tells how you felt.

1. How important to you was it to learn about these shells?
   - A. Very important
   - B. Moderately important
   - C. Not too important
   - D. Not important at all

2. How much of the time in the exhibit room did you touch the shells?
   - A. All of the time
   - B. Most of the time
   - C. About half of the time
   - D. Not much of the time

3. How hard did it seem to learn about these shells?
   - A. Very hard
   - B. Moderately hard
   - C. Not too hard
   - D. Not hard at all

4. How hard did you concentrate on learning all about these shells?
   - A. Very hard
   - B. Moderately hard
   - C. Not too hard
   - D. Not hard at all

5. How much of the time in the exhibit room did you think of things that were not about the shells?
   - A. All of the time
   - B. Most of the time
   - C. About half of the time
   - D. Not much of the time

6. How much effort do you think you put into learning from this exhibit?
   - A. Very much effort
   - B. Moderate amount of effort
   - C. A little effort
   - D. Really not much effort at all

APPENDIX F
FACTUAL POSTTEST AND INFERENTIAL POSTTEST

LET'S SEE WHAT YOU LEARNED FROM THE SHELL EXHIBIT

DIRECTIONS: Put your answers in the blanks on the right.

1. What color was the biggest shell? 1. ________

2. Was that biggest shell a univalve or a bivalve? 2. ________

3. What was stuck inside one shell? 3. ________

4. In which corner did you see a shell that had a look of pearl inside? 4. ________

5. What is the name of the animals the exhibit said made these shells? 5. ________

6. What color was the very shiny ceramic looking shell? 6. ________

7. Where did these shells originally come from? 7. ________

8. What do you call a shell that has two halves that look alike? 8. ________

9. Was the very shiny shell rough or smooth? 9. ________

10. Why do animals make shells? 10. ________

11. A few of the shells had holes in them because: 11. ________
    A. the animals needed to breethe
    B. the shells were old
    C. they were made that way
    D. the action of sand and water made the holes
    E. I don't know

12. One shell had one small half and one large half because it: 12. ________
    A. is not a real bivalve
    B. is broken
    C. had two different animals in it
    D. was still growing
    E. I don't know

13. Shells have different colors because of:
    - A. the way they are collected
    - B. the sand where they were found
    - C. their hardness
    - D. heredity and the type they were
    - E. I don't know

13. ________

14. Shells are hard because they:
    - A. are used for ashtrays
    - B. are not made by humans
    - C. are like skeletons
    - D. harden in the air
    - E. I don't know

14. ________

15. The ridges or lines on shells:
    - A. are different on different shells
    - B. depends on the shell's shape
    - C. depends on the shell's color
    - D. is because of the action of water and sand
    - E. I don't know

15. ________

16. Some shells are larger than others because they:
    - A. contained more water
    - B. grew older
    - C. grew faster
    - D. grew slower
    - E. I don't know

16. ________

17. Draw the shape of the animal that used to live in the very dark, skinny shell:

18. Below make three drawings:

    - A. Draw a shell with a small baby animal inside it.
    - B. Then draw the shell after the same animal grew and was about a year old.
    - C. Last, draw the shell after the same animal grew to be five years old.

APPENDIX G
SCIENCE CURIOSITY POSTTEST

DIRECTIONS: A. This part has NO right or wrong answers.
B. After you read each sentence, decide how you feel about it.
C. Then put one of the numbers below in the blank at the right.

Use these numbers:
1 = Not at all
2 = Somewhat
3 = Moderately so
4 = Very much so

A. The shell exhibit was very interesting. ______

B. I found it hard to think so I could learn about the shells. ______

C. I thought it was fun to learn and understand things about shells. ______

D. I felt that the shell exhibit was boring. ______

E. I enjoyed learning about some shells that were new to me. ______

F. I enjoyed seeing and learning new things about shells in general. ______

G. I lost interest when I had to think about how shells were the same and different. ______

H. I would rather learn about shells from a book or from the teacher. ______

APPENDIX H
CORRELATION MATRIX OF TESTING MEASURES
(With Corresponding *p* Values)

	VB[a]	GC	SC	AIME	FACT	INF	PGC	PSC
VB	1.00	.07	.06	.15	.32	.22	.05	.18
	.00	.46	.48	.08	.0002	.01	.54	.05
GC		1.00	.39	.17	.09	.26	.37	.27
		.00	.0001	.06	.31	.004	.0001	.002
SC			1.00	.27	.03	.22	.35	.35
			.00	.002	.74	.02	.0001	.0001
AIME				1.00	.16	.13	.25	.45
				.00	.07	.13	.005	.0001
FACT					1.00	.26	.14	.03
					.00	.004	.13	.76
INF						1.00	.14	.23
						.00	.13	.009
PGC							1.00	.39
							.00	.0001
PSC								1.00
								.00

[a]
VB = Vocabulary
GC = Pretest General Curiosity
SC = Pretest Science Curiosity
AIME = Amount of Invested Mental Effort
FACT = Factual Scale
INF = Inferential Scale
PGC = Posttest General Curiosity
PSC = Posttest Science Curiosity

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BIOGRAPHICAL SKETCH

Wilhelmina Mauer Fire was born on December 24, 1936, in Youngstown, Ohio. She attended Youngstown State University on a scholarship and completed the required 3 years to become a nationally registered medical technologist. In 1957, during her year of internship, she married Charles C. Fire and subsequently had three children. She worked as a medical technologist for 14 years in the laboratories of St. Elizabeth Hospital Medical Center and taught in the associated school of medical technology for 4 years.

After 16 years of intermittent study, Mrs. Fire earned a Bachelor of Science in medical technology, cum laude, from Youngstown State University. In 1971, she received a Bachelor of Science in Education, cum laude. She then taught eighth grade life science and seventh grade general science and reading at East Middle School in Windham, Ohio, before moving to Miami in 1973.

At the Summit Academy of Learning in Miami, Florida, she created a science department by designing the classroom and laboratory facilities in addition to developing the science curricula. She was also the master teacher for these sciences which ranged from general science to chemistry, zoology, human physiology, and microbiology. During her tenure at the academy, she received the Presidential Award for Excellence in Teaching (1974) and was nominated the Outstanding High School Teacher of the Year (1976).

Mrs. Fire joined Bascom Palmer Eye Institute/Anne Bates Leach Eye Hospital at the University of Miami School of Medicine to supervise, organize, and to restructure the microbiology laboratory. In addition to these responsibilities, Mrs. Fire was the inservice instructor and infection control practitioner. During this period, she was a graduate student at the University of Miami; she graduated in 1979 with a Master of Science in Education.

She continued at Bascom Palmer and joined the part-time faculty of Miami-Dade Community College, Medical Campus, as an instructor in microbiology lecture and laboratory. Mrs. Fire was an invited faculty member to the American Society for Microbiology National Conventions in Las Vegas (1978) and in Miami Beach (1980) to organize and conduct workshops on ocular microbiology. Mrs. Fire privately tutored mathematics, statistics, chemistry, and microbiology from the early 1970s until recently.

In 1980, Mrs. Fire decided to pursue a doctoral degree. Her first year was spent in a cooperative program between the University of Florida and Florida

International University. However, after the prescribed summer on campus at Gainesville, she decided to join the full-time program at the University of Florida in order to maximize her learning potential. She resigned from both her positions and moved to Gainesville where she lived for two years. She finally had the opportunity to "go away to college" at the age of 45!

Mrs. Fire was a graduate research assistant in the Department of Special Education and both a graduate research assistant and graduate teaching assistant in the Department of Instruction and Curriculum while studying at the University of Florida.

Dr. Fire presently is an Assistant Professor of microbiology at Miami-Dade Community College, Medical Campus, and is the resource person on Acquired Immune Deficiency Syndrome. She also is a guest lecturer on research design and statistics at Nova University.

Her professional affiliations include: Kappa Delta Pi Education Honorary, Phi Delta Kappa, Phi Kappa Phi Scholastic Honorary, Association for Supervision and Curriculum, National Science Teachers Association, American Society for Microbiology.

In her leisure time, Dr. Fire collects antique bells and commemorative stamps. She expects to have more time now that her education is completed and that all of the children are working professionals: Kathy is a microbiologist, Karen is an SLD (Specific Learning Disabilities) teacher, and Ken is a music teacher and band director.

In the future, Dr. Fire hopes to continue to be an effective educator while publishing some of the many articles formulating in her mind. She and her husband look forward to traveling and relaxing, that is, until another challenge beckons around the next corner.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

John J. Koran, Jr., Chairman
Professor of Instruction and
Curriculum

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Mary Lou Koran
Professor of Foundations of
Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Elroy J. Bolduc, Jr.
Professor of Instruction and
Curriculum

I certify that I have read this study and that in my opinion it conforms to aceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the College of Education and to the Graduate School and was acepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1985

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